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BULLETIN OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Vol. V LANCASTER, PA., APRIL, 1915 No. 8

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President Raymond Allen Pearson,
Iowa State College.

See page 5.

BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

ANSON MARSTON, H. H. NORRIS, F. L. BISHOP, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. V LANCASTER, PA., APRIL, 1915 No. 8

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EDITORIAL.

The Ames Meeting.—Preparations are well under way for the 1915 meeting at Ames. Indications point to a large attendance. The Program Committee believe that the program as outlined will prove of interest to every member of the Society. The local committee have plans well under way for an exceedingly pleasant social gathering. A preliminary program will be mailed shortly. Beginning with this number of the BULLETIN we shall publish one or more articles dealing with the work at the Iowa State College, together with a description of some of the buildings and activities of the Institution.

Plans are under way for a special train leaving Chicago about 8:30 A. M., Monday, June 21, going by way of Keokuk, spending three or more hours at Keokuk visiting this immense development of the Mississippi Power Company, leaving there about 8:30 or 9:00 P. M., and arriving at Ames early on Tuesday morning. This should prove a particularly interesting and valuable part of the meeting for members residing east of Chicago, as it will add one social day to the convention.

Psychology and Teaching.—The paper by Professor Angier, printed elsewhere in this issue, is of the type that the officers of the Society have been seeking for some time. When Professor William T. Magruder was president, one of his ambitions was to secure a paper on the science of teaching for presentation at the annual meeting of that year. While a number of possible writers were eminently qualified to write what was wanted it seemed impossible to induce one to undertake the task. In the first place the Society did not know just what it wanted, although there was a feeling that attention was being directed more to the art than to the science of teaching, to practice rather than principles. In the second place those invited to write evidently did not know what the Society wanted either. In the meantime, Professor Angier has written for another society just what this one was after. That it was

well received is indicated by the fact that it was repeated by request after an interval of several months under the same auspices.

The paper is a practical one. It is of the kind that will be read more than once, and teachers will pass it on to their students whom it will greatly benefit and encourage. The "plateau of learning" like the "slough of despond" is a feature of psychogeography with which we are all familiar. It is well to have its place in the landscape properly defined so that the tedium of the necessary journeys through it may be relieved by anticipation of the invigorating climbs beyond.

H. H. N.

The Engineer of the Future.—Many engineers to-day appreciate the fact that their training as students of engineering was lacking in some particular, but just exactly in what particular and how the training failed to help as it should is not always clear. This arises partly because of the fact that teachers of engineering and the faculties in our schools of engineering fail to appreciate the many fields into which the engineer of to-day is to enter. Engineering no longer consists of merely designing bridges, dynamos, and engines. In fact it has been said that not over one-tenth of one per cent of our engineering graduates are engaged in design work. Nevertheless a large part of the engineering curriculum is devoted to this phase of engineering. Today we find more and more of our graduates entering into the operation and management of public service and other corporations which require a thorough knowledge of the fundamentals of accounting and financing together with a comprehensive knowledge of the relation of public service corporations to federal, state and municipal authorities. It is needless to call attention to the ever-increasing field of activity now being occupied by the engineer.

LETTERS TO THE EDITOR.

My dear Dr. Bishop: In response to your request for a word on the attendance of teachers at engineering school conventions, let me say that last year we adopted the policy of giving all major professors and a part of our senior instructors the opportunity of attending conventions of their societies. We consider this as institute work and a necessary charge on the institute funds. Each professor is supplied before leaving the institute with his railroad and pullman fares and six dollars a day for expenses. The amount which he uses is optional with him. He may use the total six dollars or more a day and make no returns. If he uses less he notes his own accounts and returns any difference. Every member of our major faculty, and several of our minor faculty have now taken advantage of this opportunity and have been away from the institute in attendance on conventions or meetings.

As regards the Society for the Promotion of Engineering Education, I may say that we offered the opportunity to all the staff, of every grade, who desired to do so, to attend the meeting at the expense of the institute, the meeting being held at Princeton this year. I know personally that I would not consider missing the conventions of the two national engineering societies—the American Society of Civil Engineers, and the American Society of Mechanical Engineers—of which I am a member. My only reason for being forced to omit occasionally the Society for the Promotion of Engineering Education is the fact that the meeting comes for me at one of the busiest times in the year, when our committee on admissions is determining who will be admitted to the institute during the coming academic year.

I have by no means, however, given up the expectation of being at Ames, June 22–25.

Yours very sincerely,

HOLLIS GODFREY,
President, Drexel Institute.

PERSONALS.

RAYMOND ALLEN PEARSON,

President, Iowa State College.

Raymond Allen Pearson was born at Evansville, Ind., April 9, 1873. He graduated from Cornell University, College of Agriculture, in 1894, taking his M.S. degree in 1899, and the degree of LL.D. from Alfred (N. Y.) University in 1910.

From 1895 to 1902 he was assistant chief of the Dairy Division, U. S. Department of Agriculture, later serving for one year as general manager of the Walker-Gordon Laboratory Company, New York and Philadelphia He then became professor of dairy industry, college of agriculture, Cornell University, serving in this capacity until 1908. From 1908 until March, 1912, he served as commissioner of agriculture, State of New York, then accepting the presidency of the Iowa State College.

President Pearson is actively interested in the S. P. E. E., and many other scientific and agricultural societies. In 1900 he received a gold medal at the Paris Exposition as collaborator. He has written several bulletins published by the U. S. Department of Agriculture and Cornell University, as well as numerous articles on dairy subjects for magazines and the Encyclopedia Americana.

President Pearson appeared before the council of the Society at Princeton and extended a personal invitation to the Society to meet in Ames in 1915. This invitation was accepted by the council and the date fixed for June 22–25.

SOCIETY BUSINESS.

TREASURER'S MID-YEAR STATEMENT.

March 8, 1915. (*Approximate.*)

Received to date, for current dues	$3,682.29
Received to date, for back dues	477.50
Received to date, from other sources	1,370.01
	$5,529.80

Cash on hand, June 16, 1914	1,771.64
	$7,301.44
Paid out to date	5,764.48
Balance on hand	$1,536.96
Current dues outstanding	2,080.20
Back dues outstanding	869.76
Due from other sources	230.75
Total	$3,180.71

EVERY OUTSTANDING DOLLAR MUST MOVE IN.

The doctor has always had the distinction of being the last one paid, but it seems as though he is about to pass it on to the Magazine. It will be all right with the Magazine for him to keep it. "Distinction" doesn't go as legal tender with the printer, the engraver or the postmaster. The Alumni Association is now paying interest on borrowed money—with many alumni owing dues for from one to six years. If every outstanding dollar would move inside it would be possible to forget that several hundred alumni took that two per cent discount. Bills go out this week. Every one of them could and should be paid the day it is received.—*The Graduate Magazine, University of Kansas.*

No comments are necessary. THE EDITOR.

SOCIETY NOTES.

Our readers who have studied Professor Deimel's article in the February BULLETIN entitled "The Equation of Rotation" were probably forced to give up in despair. The diagrams which were published with this paper belong to an article not yet published. The correct diagrams appear below. It is much to be regretted that Professor Deimel's excellent paper was marred in this way.

Through an oversight one of our newest and most progressive institutional members, the University of Virginia, was omitted from the 1915 year book. The University made application for membership as an institutional member just as

the year book was going to press, and the correction which was made on the page proof was somehow overlooked. The University of Virginia is now represented in the membership of the Society to the number of six.

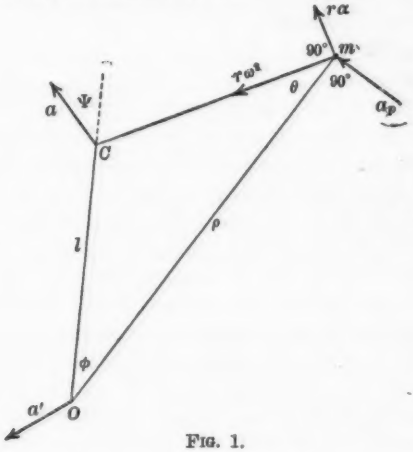


FIG. 1.

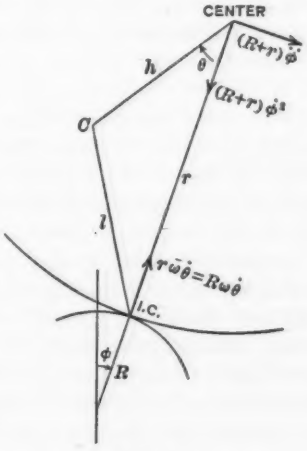


FIG. 2.

The following letter is printed just as received without editing by the Secretary or his assistant, in order to avoid further error.—THE EDITOR.

DEAN F. L. BISHOP,
University of Pittsburgh,
Pittsburgh, Pa.
Dear Sir:—

I regret very much the necessity of calling your attention to another mistake, the third that has been made with reference to me by the BULLETIN within the past few months and not one of these mistakes were in any way called for as I had carefully typewriten all statements. Notwithstanding the fact that my letterhead clearly indicates my position here and that I have written to you several times trying to get you straight on the matter, your assistant who made up my contribution insists on specifying me as *Assistant* Professor. I wish to call your attention again to the fact that my title here is Professor and that I am in charge of the department of mechanical engineering and I trust that you will correct the error made.

One of the things that my article emphasizes is the method of instilling an attitude of responsibility and self reliance into my students. I have succeeded so well that if any of my junior engineers at M. A. C. were to make three mistakes in so short a time on the same thing, especially when, as in this case the matter submitted was so plain, I would have called him down so effectively that he would never forget it. I submitted to you my name, position and address just as it should appear in the directory, I sent you similar data for publication among the changes of position, I asked you to correct the mistake of attaching my name to the University of Oklahoma and stated at that time clearly my position here and I clearly pointed out how my name should appear with reference to my article which according to your letter of January 6 which I am enclosing herewith must have been understood by you but notwithstanding thiscare and the clearness of direction the

mistake is persistantly thrust upon me. I would recommend that your assistant, who is responsible for all this blundering, read a "Message to Garcia" which was written a few years ago by Elbert Hubbard also, on first occasion, that he ask Mr. F. W. Taylor what is most lacking in the average engineering graduate.

I feel that it is absolutely necessary now to check up the insertion concerning me that is to appear in the new directory and I would be glad if you will submit a proof of that portion of the new directory when it has been struck off.

I would also be glad if you will send me the ten (10) reprints of my article as requested in my former letter.

Yours very truly,

(signed) EDWARD J. KUNZE

A SUMMER COURSE FOR ENGINEERING TEACHERS.

During the past four summers, the Educational Department of the Westinghouse Electric and Manufacturing Company has offered an opportunity for engineering teachers to spend several weeks at their East Pittsburgh works. A program of inspections, talks, and discussions was held, so that each teacher became acquainted with the apparatus and work of the other sections besides the one in which he was employed. Inspection trips to several interesting industrial plants of the Pittsburgh district were arranged; conferences on educational problems were held; and there were opportunities for talking with representatives of the engineering, manufacturing, and sales departments. One of the most pleasant features of the course was the social evening, the dinner given by the University of Pittsburgh being worthy of special mention.

The results of the course for the past four summers have been such that the Educational Department has announced a course for the coming summer, the schedule of which is as follows:

Schedule of Work for the Summer Course for Engineering Teachers—1915.

1. The length of the course will be five weeks, from July 6 to August 7.

2. Those who are coming should report for work July 6 but may leave any time between Aug. 7 and Sept. 15. There will be no closely supervised schedule excepting for the five weeks mentioned above.

3. Employment will be in the Testing Department, the Manufacturing Department and the Engineering Department. Every effort will be made to provide that work and experience which each visiting teacher desires. There will be little opportunity for transferring from one department to another, as the time is too short, except among the manufacturing sections where transfers may be made every two weeks if desired.

4. The rate of pay will be 22c. per hour which is sufficient to cover living expenses. A full working week will comprise 54 hours for any and all departments.

5. Monday, 7:45 to 9:15 A. M. Factory inspection trip led by an engineer or other expert.

Monday, 9:30 to 10:30 A. M. Talk and discussion on apparatus inspected.

Tuesday, 8:00 to 9:30 P. M. Meeting at Westinghouse Club with W. E. & M. Co. men for discussion of engineering, educational and commercial subjects.

Thursday, 7:45 to 9:15 A. M. Same as Monday.

Thursday, 9:30 to 10:30 A. M. Same as Monday.

Friday, 8:00 to 9:30 P. M. Informal gatherings of teachers at Westinghouse Club for discussion.

Saturday, 1:00 P. M. to 6:00 P. M. (Subject to change.) Inspection trips to various plants and industries in the Pittsburgh district.

6. Applications should be sent in before April 1. All applications will be replied to before May 1.

It is planned to open this summer's course with an educa-

tional conference at the University of Pittsburgh to be followed by a dinner and social evening with the University as host.

BOOKS RECEIVED.

Plain and Reinforced Arches. By J. MELAN. Published by John Wiley and Sons, Inc.

American Hand Book for Electrical Engineers. By HAROLD PENDER. Published by John Wiley and Sons, Inc.

Masonry. By MALVERD A. HOWE. Published by John Wiley and Sons, Inc.

Foundations. By MALVERD A. HOWE. Published by John Wiley and Sons, Inc.

Surveying Manual. By HOWARD CHAPIN IVES. Published by John Wiley and Sons, Inc.

Alternating Current Electricity, First Course. By W. H. TIMBIE and H. H. HIGBIE. Published by John Wiley and Sons, Inc.

Structural Steel Drafting and Elementary Design. By CHAS. D. CONKLIN. Published by John Wiley and Sons, Inc.

Mechanism of the Steam Engine and Similar Machines. By WALTER H. JAMES and MYRON W. DOLE. Published by John Wiley and Sons, Inc.

Materials of Machines. By ALBERT W. SMITH. Published by John Wiley and Sons, Inc.

Strength of Materials. By H. E. MURDOCK. Published by John Wiley and Sons, Inc.

Working Data for Irrigation Engineers. By MORITZ. Published by John Wiley and Sons, Inc.

Steam Charts. By F. O. ELLENWOOD. Published by John Wiley and Sons, Inc.

Theory of Measurements. By STEVENS. Published by D. Van Nostrand Company.

Graphical Determination of Sags and Stresses for Overhead Line Construction. By GUIDO and SEMENZA. Translation by C. O. Mailloux. Published by McGraw-Hill Book Co.

BOOK REVIEWS.

Strength of Materials. By H. E. Murdock, M.E., C.E., Irrigation Engineer, U. S. Dept. of Agriculture. John Wiley & Sons. 1914. xv + 352 pp., 5 × 7¼, 137 figures. Cloth, $2.00 net (8/6 net).

A clear, concise, and practical presentation of the subject, including reinforced concrete, without resort to the calculus; graphical methods are emphasized. Tables covering the properties of various materials and structural shapes make a handbook unnecessary. The unusually large number of problems, both with and without answers, and illustrative examples fully solved, make it a very desirable text-book for engineering students. J. S. L.

Mechanism of the Steam Engine. By WALTER H. JAMES, Assistant Professor of Mechanical Engineering Drawing, Massachusetts Institute of Technology, and MYRON W. DOLE, Instructor in Mechanical Engineering, Massachusetts Institute of Technology. John Wiley and Sons, Inc. 1914. 300 pp., 6 × 9, 225 figures. Cloth, $2.50 net.

"Mechanism of Steam Engines" is a clear and concise development of the kinematics of valve gears and governors as applied to steam engine practice. A very commendable feature in the study and construction of diagrams is the manner in which the authors emphasize the importance of keeping in mind the relative motion of all the elements of the engine.

J. W.

Surveying Manual. By HOWARD CHAPIN IVES, Professor of Railroad Engineering, Worcester Polytechnic Institute. John Wiley and Sons, Inc. 1914. viii + 296 pp., 4¼ × 6¾ Morocco.

As the author states in the preface, this book is intended primarily for non-civil engineering students. For this purpose it seems well adapted. The work combines in one small volume some of the best points of several recognized texts on

surveying. There are numerous problems covering the more elementary field work, all concisely stated and described. The illustrations are well chosen and the samples of field notes, of which there are quite a number, are rather above the average.

L. C. McC.

Structural Steel Drafting, and Elementary Design. By CHARLES D. CONKLIN, JR., C.E., in charge of Structural Design at Cooper Union Schools, New York City. vii + 154 pp., 151 figures, 9″ × 12″. Cloth, $2.50 net (10/6 net). John Wiley and Sons.

This book differs from most others of its class, in that it embodies a reasonable amount of theory which is well connected with the practical, or constructive side of structural engineering. Special attention being paid to contract estimates, drafting room methods, and economic design. The text is well arranged, and the selection of examples and figures is excellent. Many of the figures are of full page dimensions. They are well proportioned, very clear, and illustrate the examples to good advantage. A discussion of the principles of structural drawing and office practice is followed by a number of well selected typical detail designs of shop buildings, girder bridges, truss bridges, etc. Skew portals, as well as hip and valley details receive special attention.

The author possesses the ability to discuss his topics briefly, yet clearly, and with sufficient completeness. This book is excellent as a school text, or a book of reference. It should be of benefit to all structural draftsmen, whether they are beginners or men of considerable experience. J. H. S.

Materials of Machines, second edition, rewritten. By ALBERT W. SMITH, Director of Sibley College, Cornell University. John Wiley and Sons, Inc. 1914. v + 203 pp., 5 × 7¼, 36 figures. Cloth, $1.25 net (5/6 net).

In the second edition the book has been revised particularly in the part referring to the properties and treatment of

materials. While the author has aimed to make his work elementary, yet it has been made up-to-date in the same brief and thorough manner that characterized the original edition.

J. W.

Alternating Current Electricity. First course. By W. H. TIMBIE, Head of Department of Applied Science, Wentworth Institute, and H. H. HIGBIE, Professor of Electrical Engineering, University of Michigan. John Wiley and Sons, Inc. 1914. viii + 534 pp., 5¼ × 8, over 370 figures. Cloth, $2.00 net (8/6 net).

This book is an elementary text on alternating-current electricity and its application to machines. It is a well-balanced text for students, and a good reference book for the practicing engineer. It can be used earlier in the course than some alternating current texts, because of the elimination of much abstract theory. A very welcome feature is the numerous examples illustrating the theory, and the well-selected problems at the end of each chapter. The authors have gone to unusual length to illustrate the text with diagrams and cuts, while the entire development of the theory is carefully based on simple analogies, which unquestionably helps the student to form proper physical conceptions of the alternating current phenomena.

H. E. D.

Plain and Reinforced Concrete Arches. By J. MELAN, Professor of Bridge Design at the German Technical School at Prague. Translation by D. B. STEINMAN, Professor of Civil Engineering at the University of Idaho. John Wiley and Sons, Inc. 1915. x + 161 pp., 6 × 9, 43 figures. Cloth, $2.00 net (8/6 net).

It will doubtless be with a feeling of gratitude toward Professor Steinman that the American engineers receive his translation of this work. In the opinion of the writer this is the most thorough and masterly treatment of the concrete arch to be found in all our engineering literature. This text has

at least one point of superiority over most works on the subject, in combining with a complete analysis of all types of arches, many practical suggestions and short cuts which make it of special value to the designing engineer as well as the student.

L. C. McC.

FRANK OLIN MARVIN.

After several years of ill health, Dean Frank O. Marvin, of the University of Kansas, died February 6, in San Diego, California. He and Mrs. Marvin had gone to California a month previous in the hope of improvement for the dean's health. The funeral services were held in the Congregational church at Lawrence, February 11.

Dean Marvin was born in Alfred, New York, May 27, 1852. He was a graduate of Allegheny College, holding the degrees of Civil Engineer and Master of Arts. He became a teacher in the university in 1875, and dean of the school of engineering in 1891. Two years ago, he gave up the active direction of the school, receiving the title of advisory dean.

Professor Marvin's life work was the establishment and building up of the school of engineering. He came to this work in the late seventies a young man, with a good professional training, some experience in active railroad work and a very marked ability to meet young men and boys in such a manner as to win their confidence and admiration. It would seem that his qualifications for the work were ideal. He was an active and loyal member of the American Society of Civil Engineers and of all the Kansas societies for scientific research. He was one of the founders of, and was always very active in the Society for the Promotion of Engineering Education, serving as president in 1900–01, and was an active member and past president of the Society of Sigma Xi.

S. B. CHRISTY.

Professor S. B. Christy was born in San Francisco in 1853. He graduated from the University of California in 1874 and was appointed instructor of qualitative analysis immediately upon graduation, serving in this capacity for five years. He was then appointed instructor in mining and metallurgy and in 1885 was appointed professor of mining and metallurgy and held this position until his death. Professor Christy wrote quite a number of books the most important being "The Volatility of Gold" in 1888. In the year 1902 he visited the leading mining schools of America and Europe for the purpose of gaining information useful in planning the Hearst Memorial Mining Building. Professor Christy, in addition to his regular instruction work, continued his research work up to his death. At the time of his death he was engaged in writing a book which will be edited by Professor E. A. Hersam. He had been a member of the Society for the Promotion of Engineering Education since its organization in 1893 and was vice-president from 1893 to 1896. He died November 30, 1914.

WILLIAM F. GURLEY.

Wm. F. Gurley was born in Troy in June, 1860. He received his early training in that city, graduating from Williams College in 1882. On leaving college he entered the Gurley works, working in the factory, and at the death of his uncle became the head of the firm. When the company was incorporated, he became the president, a position he held until his death. Mr. Gurley was a trustee of the Rensselaer Polytechnic Institute, and of Colgate University, president of Emma Willard School and school commissioner of the city of Troy. He was prominent in numerous other activities in the city. Mr. Gurley has been a member of the Society for the Promotion of Engineering Education for the last two years and has always taken an interest in it, helping in many ways to build it up. Mr. Gurley's death came unexpectedly at Atlantic City on February 17, 1915.

COLLEGE NOTES.

Case School of Applied Science.—A moving picture lantern has been installed in the assembly room and a course of lectures illustrated with moving pictures has been inaugurated. So far, lectures have been given on "The Panama Canal and Its Electrical Equipment," "Factory Efficiency," "The Potash Industry," "The Asphalt Industry." Other lectures scheduled for this year are: "The Mining and Uses of White Lead," "Welfare Work," "The Zinc Industry." These lectures have been found not only very interesting, but very helpful to the students by teaching them methods in use in various industries.

Clemson Agricultural College.—An extension to the drill and athletic field, measuring 400 ft. by 1,000 ft., has just been finished. This required the movement of 75,000 yards of earth which was handled at the low cost of about 12 cents a yard, despite the fact that some of it had to be hauled as much as 900 feet. The work was not done by contract but by labor employed by the college, under plans and supervision of the Civil Engineering Department.

Contract has been let for a new Y. M. C. A. building to cost $75,000 equipped. The funds for this were made possible by a gift of $50,000 from John D. Rockefeller, and $25,000 raised by students and friends. This building will furnish offices and lobby, lounging, reading, and game rooms, and dormitories. It will contain an auditorium and rooms for Bible study, literary societies, lodges, and ladies clubs. It will provide bowling alleys, billiard tables, basket ball, a swimming pool, and shower baths. There will aso be a store and cafe. The structure will be of brick and tile, of the Italian Renaissance style of architecture. The plans and specifications were worked out by the Architectural Department.

The Mechanical Department has recently added to its equipment a 20 h.p. Packard automobile engine, and a 4 h.p. Mogul kerosene engine.

Columbia University.—Prof. Arthur H. Blanchard recently delivered an illustrated lecture on "Economic Phases of Highway Engineering" at the Wesleyan University. The following lectures have been delivered before the graduate students of highway engineering recently: Mr. A. N. Johnson, highway engineer, Bureau of Municipal Research, New York City, on "Methods of Cost Keeping for Highway Engineers and Contractors"; Mr. Geo. C. Warren, president, Warren Brothers Co., on "Public Recognition of and Specifications for Patented Pavements"; Capt. D. L. Hough, president, Cuban Engineering and Contracting Co., New York City, on "The Relation of the Contractor to the Engineer" and "The Highways of Russia"; Mr. Henry W. Durham, former chief engineer of highways, Borough of Manhattan, New York City, on "The Relation of Tests of Physical Properties and the Wearing Qualities of Paving Materials."

University of Illinois.—Unusual opportunities of hearing lectures of note have been enjoyed this year through the activity of the Committee on Lectures of the College of Engineering. Lectures have been given by Mr. Willard Beahan, of the New York Central lines, on "The Engineering of Men"; by Dean Edward Orton, of Ohio State University, on "The Engineer as a Social Force"; by President H. S. Drinker, of Lehigh University, on "Proper Conservation and Development of our Natural Resources"; by Mr. C. J. Hicks, of the International Harvester Company, on "Industrial Betterment and Good Business"; and by Professor W. K. Hatt, of Purdue University, on "Flood Protection in Indiana."

A special committee of the engineering faculty, appointed early this year to recommend means for improving the rhetoric of students, has submitted a comprehensive report which may be briefly summarized by two of its leading recommendations, (1) to make rhetoric a prerequisite for junior standing; and (2) to provide regulations requiring students who are found to be deficient in rhetoric after having passed the subject, to take additional work therein.

The Department of Ceramics, which since its inception has been under the administration of the College of Science, will be transferred to the College of Engineering at the beginning of the next fiscal year. Bids are being advertised for a new ceramics building to cost $120,000. It is expected that construction will begin early in the spring.

W. M. Wilson, assistant professor of structural engineering, and G. A. Maney have developed a new method for determining the wind stresses in the steel frames of office buildings, and the former presented a paper on this subject before the Western Society of Engineers in Chicago on March 8.

H. P. Thomas, engineer of tests for the Joint Committee on Stresses in Railroad Track, is conducting a series of experiments in the laboratory of applied mechanics to determine the compressibility and transmission of pressure through ballast placed under railroad track.

A series of tests to determine the relative efficiencies of various materials used in friction clutch linings is being conducted by Professor O. A. Leutwiler and Messrs. A. B. Domonoske and H. W. Waterfall, of the Department of Mechanical Engineering.

Preparatory to conducting a series of tests on drilling in metals, the Department of Mechanical Engineering has installed in the machine shop a high production drill press and drill grinder of the latest design. The tests will be conducted by Mr. W. P. Lukens, research fellow in the Engineering experiment Station, under the general supervision of Director B. W. Benedict of the shop laboratories.

Director R. Y. Williams of the Miners' and Mechanics' Institutes recently organized a night school at Duquoin, Illinois, in coöperation with the township high school, following a petition of forty miners for such a school. This is the sixteenth night school that has been organized by these institutes.

Professor A. M. Buck, of the Department of Railway Engineering, is conducting an investigation of the proportions of

resistances used in electric railway motors, with the object of contributing tabulations of standard practices.

Lehigh University.—Professor Edward H. Williams, Jr., of Woodstock, Vt., for many years head of the Department of Mining and Geology at Lehigh and now a lecturer of the University, gave two lectures in February before the students of Lehigh. His subjects were "The Geology of the Lehigh Valley" and "The Formation of the Allegheny River."

The faculty of Lehigh University, at the March meeting this week, made an important change in the requirements for admission to the engineering courses. Beginning next September, advanced algebra will not be required for admission but may be presented by candidates for elective credit toward the fourteen units necessary for admission. Instruction in advanced algebra will be given engineering students in the freshman year hereafter.

University of Minnesota.—Prof. J. J. Flather is spending his sabbatical year abroad. Professor Flather expects to take up research work in London soon. Prof. C. F. Shoop recently read a paper before the Minnesota Society of Engineers and Surveyors at their annual convention in St. Paul. The title of the paper was "The Abrasion Value of Various Concrete Aggregates in Concrete Roads."

Engineering Bulletins dealing with "Concrete Road Construction" by Professor C. F. Shoop, of the Experimental Engineering Department, and on "Secondary Stresses and other Problems in Rigid Frames, a New Method of Solution" by Mr. G. A. Maney of the Department of Civil Engineering, will shortly be issued as Research Documents of the University of Minnesota.

University of Pennsylvania.—H. E. Ehlers, professor of experimental engineering, has been granted a leave of absence to assume duties as assistant chief engineer, Public Service Commission of Pennsylvania.

The senior mechanical engineers have returned from the annual inspection trip, visiting industrial and manufacturing

plants at Pittsburgh, Pa., Cleveland, Ohio, Akron, Ohio, St. Louis, Mo., Keokuk, Iowa, Chicago, Ill., Gary, Ind., Detroit, Mich., Buffalo, N. Y., and Niagara Falls, N. Y. Prof. R. H. Fernald was in charge of the party.

The senior electrical engineers under the direction of Assistant Professor C. E. Clewell, recently visited various plants of interest at McCall Ferry, Pa., Pittsburgh, Pa., Niagara Falls, N. Y., Schenectady, N. Y., and New York City.

Dr. E. R. Johnson, of the Wharton School, addressed the Rochester Chamber of Commerce, Rochester, N. Y., March 27, on the "Panama Canal."

Washington University.—Two evening extension courses in electrical engineering have recently been started by way of experiment in evening extension work. The response to these efforts has not only been gratifying, but astonishing. The enrollment is 103 and on the opening evening it became necessary to refuse admission to many on account of lack of accommodation in the laboratory. Plans are now under way for several similar courses next year, as well as these more advanced. Results would make it appear that there is a large field for such work in St. Louis. A very interesting feature is the presence of a number of graduates of technical schools of high standing.

There has been received recently from the Department of Commerce a government license for the operation of the radio station of the department of electrical engineering. The station has been licensed as an experimental station and has been given the official call letters 9XV.

Trinity College.—Trinity College now has a substantial department of civil engineering in charge of Prof. Chas. E. Rogers. Prof. Rogers is now enjoying his sabbatical year, and in his absence Prof. H. A. Gehring has charge of the department.

University of Vermont.—Prof. George F. Eckhard, Pennsylvania State College, has accepted the professorship of structural engineering, made vacant by the resignation of Prof. J.

W. Elliott, who will engage in private practice. Mr. H. H. Khachadoorian, civil engineer for Cavichi and Pagano, railway contractors, Quebec, is assisting in the department of civil engineering this winter.

The requirement of senior thesis has been discontinued in the College of Engineering. Those seniors having fifty per cent or more of A's and B's during the first three years are given a choice between a thesis and a course in advanced mechanics, while those falling below these marks, are required to take a three-hour course covering a review of the mathematics of the first three years together with some additional matter, chiefly topics in mechanics. In this course considerable attention is given to problems and practice in computation.

Yale University.—The Sheffield Scientific School has lately acquired about 1,400 acres of land in eastern Connecticut for the establishment of a summer camp for surveying. The tract is about 45 miles from New Haven and is easily accessible by the Shore Line Electric Railway. A portion of the land was donated by Mr. Morton F. Plant whose extensive game preserve adjoins the School's property on the south. The tract is 3½ miles in length and from ½ to 1½ miles in width and embraces a portion of two small water sheds with varied topography well suited to different kinds of surveying. A portion of the tract extends for more than a mile along the shores of a small lake and upon this site buildings for the camp will be erected.

For some years past courses in surveying have been conducted on leased land in the vicinity of New Haven, but all such courses will be transferred to the camp when it is completed.

CERTAIN PSYCHOLOGICAL PRINCIPLES INVOLVED IN TEACHING.*

BY ROSWELL P. ANGIER,

Director of the Psychological Laboratory, Yale University.

I. Transfer of Training.
II. The Curves of Learning.
III. Work *vs.* Fatigue.
IV. The Doctrine of Interest.
V. Miscellaneous.

I shall first take up one of the most fundamental problems of the experimental psychologist, that of the transfer of practice, or so-called formal discipline. The question has been framed variously, as, for instance, does a given type of mental response to given material assist in making the same type of response to other material,—does memorizing figures help one to memorize Greek, or memorizing German words help one to memorize French? The old view, of course, was that memory is one among several "faculties" of the mind and that the exercising of it in any way gives it added efficiency in all ways. Is there any experimental support for this view? Another question of similar order is, does memorizing help one to reason,—that is, is there any assisting transfer of training from one *type* of mental activity to other types?

This phase of the problem generalized becomes; does mental activity of any given kind strengthen general intelligence or strengthen the mind as a whole, or, stated now with reference to the subject of study, does the serious pursuit of some

* A paper read before the Engineers' Club of The Sheffield Scientific School of Yale University in April, 1914, and repeated, by request, in December. For further discussion of the subject the reader is referred to Thorndike's Educational Psychology, published by Teacher's College, Columbia University, 3 vols., 1913–14, to which the writer was greatly indebted in preparing this paper.

one study make the mind better able to cope with all other studies? As a corollary to this last formulation, the question is often raised, if training is thus transferable, are there special subjects of study, such as the classics, or mathematics, or history, more valuable than others for general training?

The upshot of experiments on the transfer of training, not only in memory, but in other functions, is fairly definite. The general conclusion runs "that a change in one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it and the first. The change is simply the necessary result upon the second function of the alteration of those of its factors which were elements of the first function, and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes,—*e. g.*, eye movements and the inhibition of all save arithmetical impulses,—are in part common to the two functions."*

In testing whether training in memorizing long series of nonsense-syllables† improved the ability to memorize other kinds of material, it was found that some improvement usually followed. But—and this is the important point—improvement was unequal in amount with different kinds of material. If practice with the nonsense-syllables had trained any general "faculty" of memory such should not have been the case. Roughly the results showed that in proportion as the tested material was meaningless, that is, possessed in common with the nonsense-syllables the identical element of meaninglessness, the training in memorizing these increased the facility in memorizing the tested material. Roughly in proportion, however, as the tested material, such as connected prose, had meaning, the helpful influence of the nonsense-syllable train-

* Thorndike, E. L., "Educational Psychology," 1903, pp. 80–85.

† Syllables without meaning formed by placing a vowel between two consonants, such as *bof, mox, ceb, sof, guk.*

ing decreased, since here the two kinds of material had fewer common or identical elements.

It appears, then, as results of these and other experiments,

First, that there is no such thing as a general faculty of memory;

Secondly, that there is no such thing as a general faculty of any kind;

Thirdly, that there is no such thing as general intellectual power in the traditional meaning of the term. Such terms mean, if they mean anything, that a given activity, such as memorizing, is made up of different part-processes and that these are identical in some and different in other tasks; that one's mental ability as a whole is also made up of multitudinous part-processes and that if the practicing of any given function is to be transferred as increased efficiency to the mind as a whole, it is because identical elements or part-processes are concerned in both. These, of course, may be trained whenever and in whatever task they are exercised, because they are identical in the different tasks.

But, it may be replied, you are drawing a distinction without a difference; since experiments show that there may be a positive transfer of efficiency from one memory-task to another, is not the outcome the same as if a general "faculty" of memory had been trained? Not at all, for, as I have already indicated, just to the extent that the elements in various situations are different and not identical, we find no such positive transfer. Since the chief importance of our experiments lies in this fact, let me single it out for concrete elaboration by referring to a type of experiment different from that already considered.

It concerns the ability to learn to hit a target placed under water. The tests were made on boys in grades 5 and 6. "One group of boys was given a full theoretical explanation of refraction. The other group of boys was left to work out experience without theoretical training. These two groups began practice with the target under twelve inches of water. It is a very striking fact that in the first series of trials the

boys who knew the theory of refraction and those who did not gave about the same results. That is, theory seemed to be of no value in the first tests. All the boys had to learn how to use the dart, and theory proved to be no substitute for practise. At this point the conditions were changed. The twelve inches of water were reduced to four. The differences between the two groups of boys now came out very strikingly. The boys without theory were very much confused. The practise gained with twelve inches of water did not help them with four inches. Their errors were large and persistent. On the other hand, the boys who had the theory, fitted themselves to four inches very rapidly."*

Now in this experiment we find an actual interference of habits—an actual decrease in efficiency after training—when the conditions are altered, unless, indeed, the identical element of a general principle or law is operative in the differing sets of conditions. The mere exercise of a function does not, therefore, increase any general power. If the various experiments showed nothing else, they would be worth while because they shatter this old educational dogma. This view assumed that there could be only a *positive* transfer in efficiency from specific training to general ability, an assumption that led, of course, to utterly wrong educational theories; that, for instance, the classics are of unique value for general intellectual training, that drilling in memorizing words, poems, etc., in a foreign language necessarily helps the faculty of memory in all other things, that learning the general abstract principles of a science would enable one to deal with their practical applications. The error in this last assumption is that the connection between general laws and the specific cases must be shown, their identical factors pointed out. Otherwise a student stows away his general principles in one compartment of his mind and learns by trial and error his specific cases and stows them in another compartment, and never thinks of connecting

* Judd, C. H., "The Relation of Special Training to General Intelligence," *Educational Review*, 1908, Vol. 36, p. 37.

the two. Reasoning about general laws does not necessarily help one to reason about specific applications.

Quite in opposition to this older assumption that the effect of practice is always to add a positive increment to general ability, our experiments—to summarize their net result—show that, while there is always a transfer of some kind, this may be either positive or negative. It is positive if there are identical elements in the different situations; it is negative if there are not. In the dart experiment, to repeat, a previously acquired training actually interfered, in the case of one of the two groups of boys, with the skill in throwing the dart when the conditions under water were altered. We have many cases in everyday life of such negative transfer of function. Students who come from schools in which training is chiefly mechanical memory and the acceptance of dogmatic statements of teachers find it much more difficult to adopt the attitude of learning the essential points in a subject that college education requires, or the attitude of looking upon everything as a problem and settling it for themselves rather than depending on the dogmatic authority of a teacher. One often sees it stated that teachers of singing much prefer to get their students fresh, before they have learned other and perhaps wrong methods. Transfer, in other words, while always present, may be either positive or negative.

What sorts of elements are there that may be identical in different tasks? There are several types, but for further emphasizing the practical import for teaching of the doctrine of the transfer of training, let me select one,—the identical use, in different situations, to which certain attitudes cultivated in a student may be put.

First among many I may mention the attitude of verification, of asking for evidence instead of reasoning on general assumptions. That this is of importance may seem trite and obvious, but how often one finds otherwise well educated persons arguing from general assumptions or hypotheses which they have not first subjected to verification. Their conclusion may be logically correct, but they overlook the necessity of a

prior substantiation of their assumptions. Now this fault I believe teachers to be largely responsible for. Since verification is an obvious and familiar process to them they unconsciously feel that it must be obvious and easy for anybody. Consequently they do not deliberately insist enough in class room and laboratory on getting the evidence from any student for his statements. They often accept a statement from a student if it is true, instead of insisting on the far more important thing, namely, does he know the facts which evidence its truth? The attitude of verification cannot, in short, be cultivated by simply insisting that students must verify. No amount of hammered-in precept will cultivate an attitude. An attitude of verification develops only after many individual acts of verification. It is the mental deposit which is left by much practice with concrete instances. And it is obvious that it can play a rôle in different verifiable situations because it is an identical habit of response to all such situations.

Another vital attitude is the so-called problem attitude. It ought to be the business of teachers to interest those who are capable of any intellectual exertion at all to approach situations as problems and not as something about which authoritative dogma may be had. The student should be taught to doubt, to question, to weigh. Only so can the problem attitude be cultivated. Some instructors do not encourage this. They prefer to state in the class room what is what, and they do not often enough abdicate their authority by confessions of ignorance. Such instructors do incalculable harm to their students. Abstractly any of them would say that of course he wants his students to approach things with the problem attitude, but if he is in reality dogmatic and does not insistently encourage doubting and questioning he is doing everything he can to inhibit the actual cultivation of the attitude. Here again precept amounts to nothing. The students must have the practice day by day of questioning assumptions, of looking upon anything that is told them as a problem and not as a dogma, if they are to develop as a fundamental part of their

mental fiber the problem attitude in their later careers. To feel this problem attitude as the very marrow of our bones would constitute the truest prophecy of intellectual democracy. How admirable and at the same time how enormously difficult it is to cultivate the attitude as a really inalienable spring of action receives sad and solemn witness from the world-wide discussions centering about the present war. Men who in the piping times of peace leave no hypothesis unverified, no situation unquestioned, do now, in the eruption of primal passion, assert with no thought of verification, dogmatize without a shred of their life-long problem attitude remaining to distinguish them from their aboriginal ancestors. There are, it is true, refreshing exceptions, but these serve only to point the truth that the attitudes of which I speak are supremely desirable and supremely difficult to implant as indestructible habits. We, whose business it is to cultivate them, in ourselves and in others, cannot be too soon nor too untiringly about our task.

A further attitude which it is worth great pains to cultivate is the attitude of satisfaction with improvement, with accomplishment. Most people have not the intellectual acumen to realize when they are improving and when they are not. A poet on a desert island certainly might write good poetry and he might write bad poetry, but I imagine that he would not know which was which until his fellow human beings began to approve of certain of his work and to disapprove of other. Students ordinarily lack this ability to recognize what they should and what they should not approve in their own work. They find that they have certain marks in their courses, or for a laboratory report, but they do not know just what has been good or bad to produce these marks. Likewise in the class room a student recites, the instructor calls on the next, and no student, perhaps, has by any word from the instructor realized how near or how far from the mark he has hit in his replies. It seems to me that we should emphasize more by our own approval occasions when a student, ordinarily

careless or dull, shows some insight, some scrap of knowledge that we had not suspected. For carelessness is often but a symptom of unaroused interest, and dullness a mask for a student's inability himself to recognize his mediocre from his good work. Until he can do this he cannot cultivate the attitude of satisfaction with improvement. And yet this is one of the most powerful of agents in efficient work, a fact brought out not only by general observation, but by laboratory experiments. It is as true for rational man as for instinctive brute that efficiency rises in proportion to the satisfactions that work brings and falls in proportion to the dissatisfactions. I shall emphasize this again in another connection. By commending any sign of improvement in a student one emphasizes the correct relationships that he is establishing in his work and he himself gradually learns to recognize and to take satisfaction in subtler improvements when he makes them, and a permanent attitude develops, enabling him to fix right connections and unfix wrong ones. Even graduate students decidedly need this type of guidance; the practice of some teachers of leaving them to work out alone their own salvation is quite indefensible.

And, finally, an attitude which can be used in identical manner in different fields of work is that of invariably trying to connect a general principle with its practical applications, and, conversely, of linking the individual applications to their appropriate general principles. This is very important. In studying pure science, its general principles should never be allowed to evaporate or be stowed away in some locked compartment of the mind without immediate and varied concrete illustration. For young men are too prone to keep their abstract principles in one mental chamber and their practical dealings with facts in another. Conversely, when one is dealing with applied science, with the individual applications themselves, the reverse attitude should be developed,—of linking the specific applications with the general principles which they exemplify. If these things are not done any pure science may degenerate into a training in abstract principles and

a school of applied science into a training ground for technicians.

I have mentioned but a few of the attitudes that work for a positive transfer of specific training in given situations to general efficiency in other situations. To recur to the principle that I mentioned at the beginning, the transfer of specific training to general efficiency is positive in proportion as the situations dealt with involve identical elements; it is negative so far as they involve non-identical elements. Now, it is obvious that the attitudes considered may be each involved as identical features throughout a great range of situations. They become, therefore, powerful instruments of general control, their general character depending, however, not on the cultivation of any traditional "general faculties of the mind," but on the fact that a specific response to specific stimuli may be made a constituent part of any situation in which these arousing stimuli occur. But such attitudes can be cultivated, since they are dependent on specific habits of response, only by incessant practice with the situations that evoke them, as in the case of the formation of any habit.

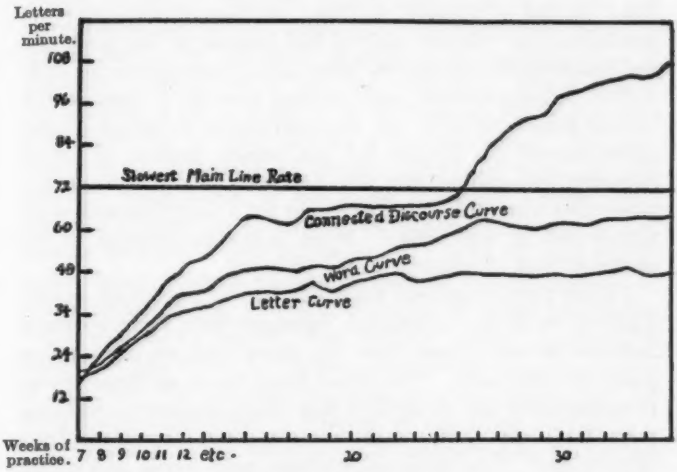
This leads me to a final remark concerning the influence of special training on general ability or efficiency. What can one say to the old question of the inherent disciplinary value of certain branches of study, such as Greek, Latin, mathematics? It appears to me that the most that can be said (so far as disciplinary value alone, and not the value of the subject-matter *per se*, is concerned) is that certain subjects lend themselves more easily than others to the cultivation of attitudes and principles identically applicable throughout a wide range of phenomena. Mathematics, for instance, if it is to be learned and understood at all, must inculcate specific principles (specific habits of response) of wide applicability,—must teach, *e. g.*, what is meant by presupposition and inference and proof. In such a thing as history, on the contrary, the invitation to cultivate these habits of such wide identical application is not so obvious. And yet a keen teacher of history might do more to cultivate incisive and precise reason-

ing than a poor teacher of mathematics. For us, in practice, the matter really resolves itself to this: it is better to see that we teach our given subjects so as to train generally applicable habits of thought than it is in the present state of knowledge to split our learned heads in efforts to decide just what subject has most nearly an exclusive corner on mental discipline.

The second topic that I should like to discuss, because I believe that its implications are not generally known, is the so-called curve of learning. The problem is to ascertain how one's efficiency in learning, as shown by the rate of improvement, varies in any given task during the progress of the learning. The most thorough investigation of the problem concerned the sending and receiving telegraphically of letters, words, and connected discourse. Two investigators not only made wide inquiries among expert telegraphers as to their experience, but actually instituted a series of tests, continued for many weeks, on subjects untrained or imperfectly trained in telegraphy. I shall here, for simplicity's sake, omit the results of the "sending" and give only those of the "receiving" tests. A given learner was subjected to twenty-eight weekly tests, the work for each consisting in receiving letters, words, and connected discourse; since each test involved all three tasks, the three curves of learning, reproduced in the accompanying diagram, proceed in parallel. This particular subject had already had about six weeks experience in telegraphy.

The salient features in these curves of improvement are four: first, a rapid rise in all three curves at the beginning of learning; second, a period of less rapid improvement in all three curves; third, the attainment of an approximate level in the first two curves, those for receiving, respectively, single letters and disconnected words; fourth, the third curve, that for receiving connected discourse, shows in the middle portion almost a level line, but when the other curves have reached their maximum level, it makes a pronounced and apparently unmotived rise. What I wish especially to emphasize is the interpretation to be put upon these two characteristics

of the third curve—the middle level period, and the subsequent rise.



ANALYSIS OF IMPROVEMENT IN TELEGRAPHY. Individual J. S. After Bryan and Harter.*

The term "plateau of learning" has been applied to the nearly level phase, a period of no apparent progress. Such plateaus may be paralleled in ordinary experience. We all know that in learning a foreign language we at first make rapid progress. We then appear to improve no further for many weeks or months, but finally, if we have persisted, a period of rather sudden progress in efficiency supervenes. If you will consult your memories I think that you will find similar instances in almost anything that you have undertaken. It might be said that a man's whole professional

* "Studies in the Physiology and Psychology of the Telegraphic Language," PSYCHOLOGICAL REVIEW, 1897, Vol. 4, pp. 27–53, and 1899, Vol. 6, pp. 345–375.

career is a series of rises in proficiency, of plateaus, and further rises until a maximum is reached. Furthermore, quite aside from the objective observation of halted improvement during a plateau, we have unpleasant subjective reminders of it. We are likly to lose interest in the work and get discouraged, feel that we have attacked something too difficult of accomplishment, and perhaps give up in disgust and turn to something new. All these subjective emotional accompaniments of the plateau are not merely matters of casual everyday experience, but are ordinary phenomena of the laboratory when subjects experiment for a long time with some simple task in psychology. What is the explanation of the apparent lack of progress in the plateau?

I think that it has been made out for the particular experiment of receiving telegraphic messages with some accuracy and that the conclusions from this experiment are more or less generally applicable. The initial rapid rise in all three curves is undoubtedly due to the fact that one is necessarily learning more mere data from week to week, since one starts from relative zero. One learns more letters, more words, and simple unitary phrase connections. Soon, however, the learning of these new elements begins to approach a limit. In the two lower curves, those for receiving letters and disconnected words, the rise becomes more gradual, without settling into a marked plateau, and slowly reaches a level. One becomes, that is, more adept in the relatively mechanical processes of receiving letters and words. No highly intellectual factors are involved, but in the third curve, that for receiving connected discourse, one must soon begin to connect the letters and words in increasingly more complex, significant order. A phase involving the shifting coördination of elements set in. Consequently, there cannot be high efficiency in the later stages of the third process until the other two have been mastered, that is, until the mechanics of control over the elements has reached a relative maximum. While, therefore, the two lower curves are rising slowly the third curve comes

to almost a dead level, constituting a plateau. As soon as the first two curves reach their maximum the mind is free to devote its entire attention to the connecting of letters and words according to their meaning. The third curve begins its second rapid rise, therefore, as soon as the mechanization of the lower order of habits has been perfected. The length of the plateau is but a measure of the degree of difficulty that they encounter in their process of mechanization. One may thus form a hierarchy of habits; certain of these are elementary constituents of the whole hierarchy. From them habits of a higher order develop, which may themselves in turn become elements of still higher habits, and so on, each higher order rising from a plateau demanded by the process of mechanization going on within the order of habits next lower.

One can hardly assume, then, that the sudden rise from its plateau of the curve for connected discourse is as capricious as it looks. The plateau, inexplicable when taken alone, reveals itself, considered in relation to the lower curves, as a mere symptom of the necessary but unobserved and therefore discouraging preparation that is occurring before free mastery can come,—a preparation unobserved because one's whole interest lies in marking progress, or the lack of it, in the development of the higher order habits.

Let me quote one of the several accounts, given by the investigators of the progress of learning telegraphy, confirmatorn of their conclusions: "*Chemistry.* Several teachers of chemistry have reported that the progress of students during the first year's work in that subject is similar to that of the telegraphic student. There is the same period of rapid improvement in the first months, followed by a long period of slow progress. In the Indiana University chemical laboratory the latter period has long been recognized and named 'the period of depression.' At one time it was supposed by the instructors that this period of depression might be due to an inferiority in the latter part of the laboratory manual, but further experience has shown that this is not the case. An explanation of the chemist's plateau analogous to that given

for the telegrapher's plateau would be: that on the plateau the learner is constantly hampered because he cannot, on demand, remember any one of a large number of elementary facts which he has once learned; that the large number of elementary facts which he needs to know makes his progress toward sufficient mastery of them very slow; that a rapid progress comes at last when he can turn his attention from mastering the elements to a freer use of these facts in attacking more complex chemical problems. The chemists whom we have consulted incline to regard this explanation as correct."*

I am tempted to follow the doctrine of the plateau into some of its everyday implications. I think it an undoubted fact that the students and, in later life, the men of power are those who through native persistence or necessity keep doggedly at their tasks during the discouraging plateau region, whether these be the working up through the higher courses in their college subjects, or to higher regions of professional efficiency and prestige in their later careers. On the other hand, I believe that students and men who go a certain distance in their tasks and then drop them, do so chiefly because of this lack of persistence on the plateau, when they see no evidences of progress A man may, in short, keep going in an easy subject, even if he sees no progress. He may keep going in a difficult subject, so long as he can observe improvement; but when a man of lesser fiber meets a difficult period in his work and in addition cannot see that he is progressing, one can give him, perhaps, small blame if he throws up his task and turns to something easier, or pleasanter, or newer. Certainly the inefficient ne'er-do-weels are those who do not go beyond the plateau stage in whatever they undertake. They may be men of ability, pleasant companions, full of information, but for some reason which they themselves cannot understand, nor perhaps their friends, they never attain proficiency in any one thing. I believe, therefore, that bringing home to students in their formative stage this experimentally worked

* Bryan and Harter, *op. cit.*

out doctrine of the plateau is one of the most fruitful things that can be done.

I have had many evidences from my own students of the profit that they have gotten from knowing not only that they *may* strike periods in which they do not appear to progress, but that they *must* inevitably meet them if they are to go on into the higher regions of power. When a man or a boy knows the inherent necessity of the plateau, he does not need to depend merely on native persistence, on the necessities of bread and butter getting, or on some other dire ulterior motive, in order to keep at work, because he can then realize that his ambitions can *only* be fulfilled by self-consciously sticking to his tasks when they appear most difficult and most fruitless, but that if he does stick to them the realization will come. I believe that this is one of the great benefits derived from requiring a student to choose a major subject of study in which he must progress from the elementary to the advanced stage. He gets the experience of the plateau, and if he is serious he forms a habit of going through the plateau and attaining mastery on the other side. The doctrine of the plateau can be easily and simply brought home to the many students who consult us about their work.

Certainly one phase of the doctrine of "interest" in education must receive its death blow from the plateau doctrine. I refer to the all too prevalent theory—consciously held or implicitly practiced—that studies should be kept constantly "interesting" (in a sense little different from "entertaining"); that when a subject ceases to be spontaneously attractive the time has come either to provide further novelties to jog the jading attention or to turn to some wholly new field. But the waning of interest is often but a sign that one is approaching the plateau, is reaching a period demanding a type of intellectual work which, since it can show real progress in efficiency only after the command over the elements of the subject has become automatic, is necessarily more difficult and therefore unattractive to the ordinary mind. A student may not know the psychology of his avoidance, but his prophetic soul gives

him intimations of the aridity ahead. His interest "wanes." This, you will agree, is the worst possible time to adopt the procedures just mentioned. These remarks may have, in particular, some application to many kindergarten methods; to the so-called Montessori method; to the habit of allowing students to drop a course that is proving difficult ("uninteresting," as they term it); of permitting them to take a large number of elementary courses, for all of which they receive full hour-credit; of countenancing "majors" in subjects in which no true sequence from easy-elementary to difficult-advanced stages is required, etc. There is, it is true, another doctrine of interest of real value in education, but it is not that just described.

The third topic, which I will consider briefly, concerns the matter of work and fatigue. Experiments on the influence of continued work on a given problem for, say, three, four, or more hours without intermission, have been numerous and although they differ in the details of their findings, two points stand out with compelling clearness. The first is that, granted an interest and a motive, deleterious fatigue does not occur, and this even in the case of pupils in the secondary schools. I think we need have no fear, therefore, that a two- or three-hour laboratory period or even an hour and a half recitation period is in any way too long for the powers of a student, provided that, assuming a motive for work, his natural impulses—such as to be in the open air, to exercise, to have social intercourse—are not seriously interfered with. One must bear in mind, however, that by "fatigue" is meant mental and not muscular or sensory fatigue. The sensory fatigue involved in eye-strain resulting from exacting visual work, or the muscular fatigue from constant muscular activity—often necessary ingredients in a total mental task—should, of course, be watched for and avoided.

The second result of the investigation of work and fatigue is more general and perhaps even more surprising. This is that efficiency is remarkably independent, not only of the period through which one works, but of the time of day which

one works; independent, too, of subjective *feelings* of fatigue, illness, low spirits, etc. This result appeared time and time again in careful laboratory experiments—subjects who said that they were intolerably tired, of unusually low spirits, nevertheless were as efficient, when efficiency is measured by the amount of accomplishment per unit of time, as when they felt buoyant and fresh. Our subjective emotions, in other words, are in such cases not at all reliable indicators of our objective efficiency, any more than the depressing feeling of lack of progress during the plateau period of learning is indicative of actual lack of progress.

But it has continually appeared in experimentation that efficiency cannot be maintained for long periods of work, or in the face of subjective feelings of depression or fatigue, unless the motive for persisting in the work remains strong. In other words, the importance of a strong motive or interest—a purely psychological factor—is more potent in determining efficiency than such external conditions as the period during which one works, the fatigue and depression which one feels.

Here lies the true doctrine of interest. It is really a doctrine of motive. The term "interest" is too easily confused with the doctrine of entertainment or of "being interesting." What is important is that the student should have a motive aroused that drives him to learn on his own initiative. The center of gravity here becomes shifted to the student instead of remaining with the instructor. He then utilizes the instructor's lectures merely as one means of satisfying an interest, of actualizing a motive, instead of being a passive receiver of learning, the motive for which lies in the instructor's mind, not in his own. His attitude has become dynamic.

One cannot emphasize too strongly the value of this view of the doctrine of interest or motive. As instruments of efficiency other factors are quite subsidiary. An adequate motive jeers at fatigue, makes carefully prepared systems and curricula look like outworn creeds, and gallops across boggy plateaus as if winged by Pegasus. "Inquiry at the telegraph

schools and among operators indicates that between 60 and 75 per cent. of those who begin the study of telegraphy become discouraged upon the plateau of the curve just below the main-line rate."* Why? Partly, at least, because of inadequate motive. Furthermore, long employed telegraphers, who have apparently reached their maximal efficiency, are surprised to find that under stress they can improve much further. Why? Chiefly because they have a new motive.

I am doubtless very trite in my statements. But their triteness has not prevented the rise of educational theories and practices that disregard them. It is certainly part of an instructor's business to help students to get adequate motives. No invariable rules can, of course, be laid down. The problem is too complex and rests for solution largely with the ingenuity of the instructor. But some fundamental things may be said. Perhaps the most fundamental is that exercise alone of a function will not much advance efficiency, since it creates no motive for work. The exercise must in some way bring satisfaction to the exerciser. This is a universal principle in the training of animals or of men. The organism craves normal satisfiers for effort expended. That a subject of study is good because it is merely hard and disagreeable is an outworn dogma, for it emphasizes exercise to the exclusion of satisfactions. What satisfactions should accrue in different tasks cannot be made a matter of general prescription. But one of the most universally applicable and indispensable is satisfaction that comes from mere improvement. I have already referred to this in discussing the desirability of cultivating certain attitudes in order to secure transfer of training. What I now have to say will show how it is fundamental in creating the very motives that prompt one to work at all.

It is found in the laboratory that failure to improve with practice often occurs because the workers are not informed of their results nor of the directions and amounts of their errors. They thus not only have their wrong as well as their right reactions emphasized, but—and just as important—they

* Bryan and Harter, *op. cit.*

are deprived of the normal satisfaction that knowledge of progress inevitably brings, and lack the consequent motive for further effort that it engenders. Secure the worker's interest in improvement—the satisfyingness that comes when he is trained to distinguish right from wrong reactions—and improvement appears. It is also true in the laboratory that when practice is for improvement's sake it brings greater efficiency than when undertaken to study the effects of hunger, the best periods for work, etc. Satisfaction with improvement is embedded in the original nature of man and may be made, therefore, a powerful motive for work. It is more important, I believe, than the satisfaction of successful competition with one's fellows for, first, it *involves* competition with one's previous self and, second, it creates a habit of achieving independently of social stimulus and develops, therefore, a more enduring motive for work when this stimulus is absent. Furthermore, since the motive for work born of the satisfactions that come from observed improvement is intrinsic in the work itself and not borrowed from any extrinsic motive, it is of peculiar moment for educators, who are always seeking means to inspire students with motives, derived from learning itself, which will rouse a permanent learning momentum.

That great motive-killer, the plateau, is, of course, one of the situations in which a student cannot recognize any successes, since they consist in unconscious preparation for a later noticeable increase in efficiency. The great discouragement which then comes shows negatively, but with peculiar force, how inveterately we rely, for maintaining an effective motive in our work, on the presence of noticeable improvement. The student should, therefore, have the doctrine of the plateau explained to him. If the plateau dims the motive *inherent* in the work, small wonder, otherwise, that even powerful extrinsic motives cannot make him stick to his last.

To recapitulate, the true doctrine of interest is this; one should not merely interest a student in a given situation, a given subject, but in doing something himself that yields definite satisfactions. Only thus may permanent motives for

work be aroused. Now it lies in the original nature of man and brute to find satisfaction in improved accomplishment. One does not need to urge anyone to feel satisfaction if he can observe definite improvement in his work. To see to it, therefore, that students know when and why they are improving or when and why they are not improving begets, quite regardless of ulterior motive, a powerful inward motive for further exertion.

I have been asked specifically to consider certain limited practical problems of instruction. One is, how many consecutive recitation hours should be given? Here, of course, we meet again the old difficulty,—of applying laboratory results on simplified problems to the more complex conditions obtaining in college work. And I know of no definite investigations that can be directly invoked in reply to the question. But here again there are certain general principles that enable one to form working hypotheses that may perhaps be tested by the touchstone of experience.

In the first place, as has already been stated, I do not think that we need fear that *mental* fatigue will play any great rôle in consecutive recitation periods of three or four hours, particularly since there is always an intermission between periods. And I mean, of course, effective fatigue, that interferes with efficiency, and not mere subjective feelings of fatigue, which may be discounted. But this maintenance of efficiency through three or four consecutive hours involves, again, the parallel maintenance on the part of the students of sufficient motive to keep attentive and at work. Other things equal, interest and motive will flag the longer one is kept at work, not through fatigue, but because other legitimate interests have to be checked,—exercise, conversation with one's fellows, desire to throw off strain, etc. These deprivations which natural impulses suffer by long-continued work play a very important rôle and my own prejudice is that the ideal number of hours for a morning is for undergraduates three.

But, although fatigue as a hindrance scarcely enters, there is another disturbing element that very possibly plays a part.

This is the danger of so-called competitive associations. Experiments have shown that if, after a given period of learning, say in memorizing, another similar task is set, after a short interval, but with different material, the learning of the second task inhibits the permanence of retention of the first. This checking or inhibition is undoubtedly due to the fact that the materials acquired in the first learning period are still fresh and may be stimulated by the second task to acquire new associations, irrelevant to their connections in the first task. In short, competitive associations arise and prevent the original associations from settling into a coherent whole. In general, the more similar two consecutive tasks the more is such interference likely to occur through competitive associations. It is certainly not good procedure, for instance, to follow an hour's recitation in one foreign language by a recitation in another. Doubtless some such reason, not, perhaps, accurately analyzed, has led colleges to prohibit students to begin two romance languages in the same year. It is very probable, therefore, that too many consecutive hours of recitation may interfere with the permanence of retention of what is learned, by offering competitive associations in too great number.

Another important problem concerning the distribution of working periods also deserves attention. How long intervals should be allowed between recitation periods in the same subject or course of study? Should they come once a day, once every other day, as is our usual custom, twice a week, or once a week? Here again I can offer only general considerations. Laboratory experiments on the rate of forgetting have, perhaps, something to say. It is found that after given series of material have been memorized, the rate of forgetting is rapid for the first few days and then proceeds more slowly. We are here in the presence of a very vital principle in all learning,—that the exercise of a function works for permanence of its retention, and the disuse of a function works for lack of permanence. But just how long disuse should be allowed to proceed before another learning or recitation period

follows in the same subject is a complicated question. It can be answered, in the laboratory, for any given type of learning of any given kind of material, but any answer for such complex things as courses of instruction in a complex subject must be tentative. My own impression from the experimental material is that intervals of a day between recitations are better than intervals of two days, certainly better than intervals of half a week, and that weekly recitations ought not to be tolerated,—except where, as in certain courses in literature, much intervening reading must be done, which serves to check the effects of disuse.

A further advantage of day intervals between recitations in the same course of study appears to me to obtain. During any given term a student would be running only half as many courses as he would if the recitation periods occurred only every other day. This would tend to prevent, in so far, the principle of competitive associations, already spoken of, from playing so large a rôle as it may when a greater number of subjects is taken in the same term.

Personally I believe in this so-called concentration system,—few subjects of study at a time with recitations every day. I think that the same principle applies also to laboratory work. Because of the smaller loss from disuse between recitation periods, one gains more sustained continuity in one's work, a greater intellectual momentum for the accumulating body of knowledge, and one is relieved of the necessity of carrying forward so many subjects abreast that there may be interference through competitive inhibition.

One further question has been asked me. Is it better to have recitations in the morning and laboratory in the afternoon, or the other way round? Now sleep is the most complete form of rest that we have and we should expect that after prolonged sleep one's powers would be maximal. Laboratory experiments support this view, although there is apparently a minority of individuals who seem to gain in efficiency as the day progresses, being most efficient at night. But our experiments on efficiency in simple tasks do appear

to show that, on the average, efficiency is greatest in the morning. Not, be it observed, because of any true fatigue effects appearing later in the day, for this has been found not to be the case, but because, as the day wears, the motives for concentrated work and the interest in it are likely to lapse. The natural impulses towards exercise, play, social intercourse, and relaxation from strain, even though there be no real fatigue, held in check during the work of the morning hours, necessarily seek more and more urgently for release as the day progresses. It is better, therefore, to put the more difficult subjects, or those in which the motives for accomplishment are least paramount, or the interest least spontaneous and easily maintained, in the morning hours. Whether, in your own special fields of work, this means laboratory work or recitations you alone are capable of deciding.

One thing is, however, in conclusion, again worthy of emphasis. The external regulations concerning curriculum arrangements are much less important than those great psychological determinants of efficiency,—adequate motive, dynamic interest, and adequate freedom for the play of natural impulses, necessarily held in abeyance during working periods. These, of course, are notoriously difficult quantitatively to estimate. But if a teacher feels that he has given them to his students he has given them pearls beyond price.

HIGHWAY ENGINEERING IN IOWA.

Ames, Iowa, where the 1915 meeting of the Society for the Promotion of Engineering Education will be held, is headquarters for the Iowa State Highway Commission. Its officers are in Engineering Hall, where the Society will hold its session. Dean A. Marston, president of the Society, is chairman of the Commission. This, together with the fact that State Highway Engineer T. H. MacDonald and others connected with the Commission will help entertain the Society during its visit, should especially interest the members who expect to attend the meeting, in the highway improvement work as conducted in Iowa.

For more than ten years there has been in Iowa a State Highway Commission with a State Highway Engineer. After many years of agitation the State Legislature in 1904 constituted the Iowa State College of Agriculture and Mechanic Arts, as an Institution, the State Highway Commission. Certain duties were prescribed, but no actual powers granted. The act enabled the Commission:

"1. To devise and adopt plans and systems of highway construction and maintenance, suited to the needs of the different counties of the state, and conduct demonstrations in such highway construction, at least once each year at some suitable place for the instruction of county supervisors, township trustees, superintendents, students of the college, and others.

"2. To disseminate information and instruction to county supervisors and other highway officers who make request; answer inquiries and advise such supervisors and officers on questions pertaining to highway improvements, construction and maintenance, and whenever the board of supervisors of a county adjudge that the public necessity requires a public demonstration of improved highway construction or maintenance in said county, and so request and agree to furnish necessary tools, help, and motive power for same, the commission shall furnish as soon as practicable thereafter, a trained and competent highway builder for such demonstration free to the county.

"3. To formulate reasonable conditions and regulations for public

demonstrations; and to promulgate advisory rules and regulations for the repair and maintenance of highways.

"4. To keep a record of all the important operations of the highway commission, and report same to the governor at the close of each fiscal year."

The College authorities placed the organization and active direction of this work under the Dean of Engineering and the Dean of Agriculture, who in turn appointed the state Highway Engineer.

Head Memorial Bridge—Special design—2–55¹ arches cost approximately $6,000.

Under this organization it was possible to make a broad study of the needs of the state, and a considerable amount of information was gathered which formed the foundation of later legislation. Standard plans and methods for highway improvement were also developed and distributed to public officials.

In all the detailed studies that were made in various counties and along various lines, the expenditure of the public funds raised for highway improvement received the keenest analysis. Gradually it became evident that the expenditures for bridges and culverts should be the first to be placed on a business-like basis. Just as soon as the Commission found that the culvert and bridge situation must be bettered in the

Highway Commission Standard box culvert with flaring wing walls.

State before any considerable progress could be made, the work of the Commission at once became open to the attacks of those whose interests would be affected by the placing of the bridge work of the state on an open competitive basis. Bills introduced in three successive legislatures to provide an adequate bridge law were each time overwhelmingly defeated through the influence of the lobbies maintained by bridge companies, the State Supervisors' Association Legislative Committee and other interests.

Conditions throughout the state with respect to road and bridge matters were much the same as come to prevail in any state having no centralized administrative body. From 1903 to 1911, inclusive, over 24 millions of dollars were spent on repair and construction of bridges. During this same period nearly twenty-three and one half millions of dollars, exclusive of poll taxes worked out, were spent upon the roads of Iowa. This enormous expenditure of approximately fifty millions of dollars was made without any state supervision. Those controlling the funds were not responsible to anyone, and uniformity was unknown.

Various additions, and many attempts at changes in legislation were made during successive legislative sessions. Not until the session of 1912–1913 were any comprehensive results accomplished. Then, however, there was recorded on the Statutes of Iowa an Act creating a Highway Commission with actual powers, and putting the road and bridge work of the state upon a business-like basis.

The Commission is composed of three members, one of which shall be the Dean of Engineering of the Iowa State College, at which institution the headquarters is placed by law. The other two members are appointed by the Governor. These men are not only assigned the same duties as were given to the former Commission, but are also empowered to supervise the entire road and bridge work of the state, and to enforce the provisions of the law relating thereto.

There are 104,000 miles of country road in Iowa. The Highway Commission was instructed to divide this into two systems, the first comprising the main traveled highways, not over fifteen per cent of the total, to be known as the county road system. The balance, approximately 85 per cent of the total, was designated as the township system. It then became one of the duties of the Commission to provide county officials of each county with officially approved maps showing the roads as designated in each system.

The law provided that the Commission should establish

state standards in both road and bridge building. To secure absolutely the best standards for adoption, standards that would adapt themselves best to the distinctive conditions which are met in Iowa, has required an exhaustive study of dirt road and bridge building in other states, and extensive experimenting in Iowa.

The law requires that every county must follow these

Typical cross section of Iowa Dirt road built according to Commission Standards.

standards in all its road and bridge building. It is necessary for the Commission to approve every profile and every grade on all permanent work.

The result after one full season's work has been so striking as to cause constant remark on the part of tourists and train travelers as to the uniformity of the road work, from one border of the state to the other. During the past season alone,

2,100 miles of road were put to permanent grade in the various counties. This means that hills were cut, that fills were made in low places, that at no place is the grade in excess of six per cent; that every mile of this is put to the standard cross section. If all this work had been done in a continuous line, there would be sufficient of this type of road to form six great cross state tourists' roads.

100[1] Pony Truss on concrete abutments. Cost on this type of Bridge this span approximately $4,000. Highway Commission standard.

An important feature of the Commission work has been that of eliminating danger at railroad crossings. There are 8,676 crossings in the state, 1,533 of these being on the main traveled or county system of roads. Road officials place 900 of the total crossings as dangerous. As a result of the first season's work, the work of eliminating danger has been completed in eighteen crossings, surveys and plans have been

completed on sixty, and a total of ninety scheduled for improvement during the 1915 season.

There is no provision in the Iowa law yet for extensive hard surfacing projects. It was the idea of the men who formulated the measure that it should be the foundation system to which the other features could be added; that it was better to make a start with dirt road building along scientific lines and to build up a trained and efficient road building organization, before attempting to inaugurate wholesale state aid or other hard surfacing plan. The state is going ahead putting its roads to grade, established and computed by engineers, and building grades and fills according to the best scientific engineering knowledge. These grades will be ready for hard surfacing when the proper provision is made for this work.

The Commission maintains an extensive department for the preparation of standard plans for bridges and culverts. The utmost care has been taken to design bridges of adequate strength to meet any possible needs that can be foreseen. Very little wood construction is being used and that only where absolute lack of funds, or other reasons, make it a case of necessity. Steel bridges are built to carry concrete floors. Practically all culvert work is of concrete. Ample inspection during construction is insisted upon and there is every safeguarding feature covering the letting of contracts. Competitive lettings are held on all work costing over $1,000 and all contracts for $2,000 or over must be submitted to the Commission for approval. From an engineering standpoint the bridge and culvert work has attained a higher standard than the road work. While the bridge funds of the state, which in 1914 totaled something like $4,600,000, were formerly spent for poorly designed structures of perishable material, this huge sum during the 1914 season, under the new law, was spent for work of a permanent nature.

The Iowa Road Law established the office of county engineer, the incumbent to be employed by the board of supervisors and to have complete charge of the road and bridge

building work. No bills for such work can be paid unless O. K.'d by the county engineer. The Highway Commission is given the authority to remove the county engineer, for cause. To provide the direct engineering link between the county engineer and the State Highway Engineer the state is divided into districts in which there is placed a district engineer who keeps in touch with county conditions.

The sudden demand for engineers trained in highway engineering when the law was passed could not be met. Many incompetent men secured the places. These have been and are being removed until a large per cent of the county engineers can now be classed as competent, experienced men. Within another year or two, with the experience gained by these men and with the recruits coming from the state engineering schools at Ames and Iowa City, and especially from the special highway engineering courses at Ames, Iowa will have some chance to select county engineers from men especially qualified for the work by training and experience.

Iowa, with the prospect of going extensively into the hard surfacing of her main traveled highways within a few years, seems to offer a promising field for men trained in highway engineering. The day in which the "road boss" was supreme authority on highway engineering is gone. The road foreman today is a man who knows what a blue print is for and uses it. The foremen may not be trained technical men, but many of them are today fairly well up along these lines. Now the road foreman is a man who will no more tackle the job of putting a mile of road to grade without his blue prints, which indicate to him that a technical man has made a complete study and solution of the difficulties to be met, than the construction foreman will start an important building until he has the plans at hand.

The county engineer is the one man in the county organization who is technically trained in highway engineering. He is in direct personal control of one of the largest and most

important businesses in the county. In Iowa he controls, to to a certain extent, the expenditure of approximately $100,000. This work demands a high-class man with business as well as engineering ability. The field is an attractive one today; it offers an even greater opportunity for the future. The Highway Engineering work at Ames has been established for the purpose of training men for this work and it is making splendid progress. It is kept in close touch with the work of the Highway Commission.

Members of the Society who attend this meeting will have opportunity to make a study of local methods of Highway Engineering instruction as well as of the work of the Commission with both of which President Marston is closely connected in a directory capacity.

COURSES OUT OF TERM TIME.

BY J. E. KAULFUSS,

Assistant Professor of Civil Engineering, University of Maine.

The following is the report of an investigation to determine the feasibility and desirability of requiring the University of Maine technology students

(1) To take university major subject courses out of term time,

(2) To be engaged in actual practice along their respective lines of work during at least one vacation, and

(3) To do summer reading.

The efforts of this committee have been, first, to ascertain the practice in regard to the above matters at other institutions and, second, to inquire into the environments, habits, etc., of our own students, in order to lay the pertinent facts before the faculty.

A questionnaire was sent to 89 technology colleges. These letters read:

"Dean .....,
.....,
.....

Dear Sir:

As a committee of the College of Technology, we are investigating the success of various plans designed to bring about a closer association of theory and practice in the mind of the technical student. In order to ascertain your practice toward this end, we are arranging the following questions to which we hope you will kindly give at least brief answer. Information bearing on any other phase of this subject not specifically mentioned will be appreciated.

A. Inspection Trips.

1. What students are required to make inspection trips?
2. What substitute, if any, is allowed?
3. What is the amount of time required for each trip ....., length of trips in miles ....., and average cost .....?
4. With what success are these trips carried on?

B. Summer Work.

1. What students are required to do summer work as part of the college requirement for graduation under the supervision of the engineering department?

2. What is the nature of the work and time required?
3. Under what conditions are students excused from summer work?
4. To what extent do you require that students engage in actual practice during the summer along the line of their major subject?

C. Summer Reading.

1. What students are required to do summer reading?
2. What is the nature and amount of this reading?

Trusting we may have your earnest coöperation, we are,

..... *Chairman.*"

Seventy-four replies were received, of which forty-seven were from institutions wholly or partially supported by the state. See Table I.

Inspection Trips.—The number of schools where students make inspection trips is sixty-nine, of which forty-seven require the trips to be made without any excuse therefrom, except for illness or lack of money, in which cases individual trips, reports, laboratory work, practical work or the like may be acceptably substituted. The six institutions where trips are not taken at all are Leland Stanford, Jr., New Mexico College of Agriculture and Mechanics Arts (5 students), University of Mississippi, University of Wyoming (none needed on account of summer practice), Syracuse (individual trips advised) and North Dakota Agricultural College (work not yet organized).

Time for Trips.—In general, junior and senior students in all departments take the trips which vary from local trips of a few hours to those extending 4 and 6 weeks as for mining students. Ordinarily, the time is about 5 to 7 days. Points visited vary in distance from the institution from short rides to 1,500 miles, but commonly from 100 to 300 miles. Omitting maximum and local distances, the average one way trip for 36 colleges is about 225 miles (30 state institutions).

Expense of Trips.—There is a similar range of expense from trolley fare to $150 but commonly from $15 to $50. Average expense in the above schools is about $27.

Value of Trips.—The replies spoke almost unanimously in

highest terms regarding the success with which the trips were taken.

Summer College Work.—This requirement is quite general among the better institutions and there are indications of further growth along this line. It may be said that on an average the engineering student is expected to do field, shop, or laboratory work during one summer for four weeks or two summers for two weeks each. Thirty-six schools have summer surveying for civil engineers, while about 15 have summen work for the chemical electrical, mechanical and mining engineers. Rarely are substitutes permitted.

Actual Practice Requirement.—In general, the schools urge the students in this direction and require it in but few cases. See Table I.

Institutions Requiring Summer Surveying.

The following information was obtained by a questionnaire which was sent out to 89 institutions. Sixty-eight replies were received, and from these the following 35 institutions were selected as being more or less representative. Of the remaining 33 institutions, three were located in the Rocky Mountain region and are able to place their students on surveying summer jobs; two are situated in large cities where opportunity for summer school work is poor but actual engineering practice is good; two are contemplating summer surveying; two have regular summer terms; and ten or fifteen, situated in the south, have only a handful of civil engineering students, most of whom find engineering work during the vacations and, with good surveying weather throughout the term time, need no summer field work. About fifteen of these 33 are agricultural colleges.

There is certainly a tendency for more institutions to have summer field practice, some of which appear to have this requirement for the express purpose of driving more students into actual summer work, a certain amount of which is accepted in place of the college work. This, of course, would be very difficult for us to follow here at Maine. See table II.

COURSES OUT OF TERM TIME.

TABLE II.

Explanation: "Total" means that the time "10 weeks, 6 months, and 4 weeks" are the total amounts of time put in for surveying during the college course.

Name of Institution.	No. of Summers.	Time Each Summer.	Enrollment, 1911.
1. Ala. Poly. Inst.	2	4 weeks	315 *
2. Brown Univ.	Contemplating		?
3. Case School of Appl. Sci.	3	4 weeks	505
4. Clarkson School	2	2 weeks	?
5. Colo. School of Mines	1	6 weeks	342 *
6. Delaware College	1	2 weeks	111 *
7. Iowa State Col.	3	2 weeks	576 *
8. M. I. T.	1	7 weeks	891 *
9. Mich. Col. Mines	They have regular summer terms		222 *
10. Mont. State Col.	Not necessary, because of actual practice		58 *
11. Northwestern Univ.	4	6 weeks	57
12. Norwich Univ.	3	†10 weeks	?
13. Ohio State Univ.	2	4 weeks	706 *
14. Purdue Univ.	1	4 weeks	1,212 *
15. Rose Poly. Inst.	1	2 weeks	?
16. Rutger's Col.	2	2 weeks	156 *
17. S. Dak. Mines.	1	4 weeks	41 *
18. Stevens Inst.	They have regular supplementary terms		161 *
19. Syracuse Univ.	2	†6 months	302
20. Univ. of Calif.	2?	4 weeks?	?
20a. Univ. of Ark.	3	1 week	236 *
21. Univ. of Kan.	1	4 weeks	435 *
22. Univ. of Maine	1	2 weeks	289 *
23. Univ. of Mich.	1	8 weeks	1,281 *
24. Univ. of Minnesota	1	5 weeks	537 *
25. Univ. of Missouri.	2	†4 weeks	577 *
26. Univ. of Nevada.	1	4 weeks	80 *
27. Univ. of N. Dak.	University places C. E. students		
27. Univ. of Pennsylvania.	1	4 weeks	908
28. Univ. of Vermont.	2	4 weeks	133 *
29. Univ. of Wisconsin.	1	4 weeks	763 *
30. Washington University.	2	3 weeks	145
31. West Virginia University.	1	4 weeks	89 *
32. Worcester Poly. Inst.	3	9 weeks	?
33. Yale.	1	3 weeks	?
34. Rennselaer	2	3 weeks	
35. Worcester.	2	3 weeks	

* State institutions or partially supported by the state.

† Total time required.

Number.	Institution. Name.	Eng'r. Enrolment 1911.	Inspection Trips. Students Taking Trips.	Required.	Substitute if Any.	Duration of Trip.	Round Trip in Miles.	Cost to Student.	Results, etc.	Summer College Work. Required of	Number of Summers.	Total No. of Weeks.	Nature of Work.	Substitute if Any.	Students Required to Engage in Actual Practice During Summer Recess.	Reading. Summer. Amount, Etc.	Summer. Nature.	Seminar. Credits.	Seminar. Required †	Number.
1	Alabama Poly.	315	All	No	Problems or lab.	4 to 6 days	300	$25.00	"Moderate success; expense objectionable"	C. E.	2	8	Surveying	"Very similar work"	"Advised to do so"	None		0		1
										Min. E.	1	4	Inspection trip						
										E. E. and M. E.	1	2	Mechanical lab.						
2	Armour Inst. of Tech.		Juniors and seniors	Yes	None	"In Chicago"		Nominal	"Very satisfactory"	None					"Most do in Chicago"	Advised	Chosen by instructor	0		2
3	Brooklyn Poly.		Seniors	Yes	"	4 days	300	$30.	"Fair"	None					None	None		0		3
4	Brown University		Adv. courses	Yes	"	Afternoons		Nominal	"Very good"	C. E. Dept. now advocating summer camp					"Not required"	"		0		4
5	Case Sch. Appl. Sc.		Juniors and seniors	Yes	"	2 weeks		$100.	"Very valuable"	All	3	12	Lab., field, and shop	"Equivalent in practical work"	"Most do"	"		1	Yes	5
6	Clarkson College		None	No	Regular summer supplementary terms					All	2	4	Lab., field, and shop	"Extensive knowledge by practice"	"More than half urged"	Not yet		1	"	6
7	Clemson Agr. Coll.	307	Juniors and seniors	No		1 week	300	$18.	"Excellent"	None					None	For back students		0		7
8	Colorado Sch. Mines	342	All	Yes	"None at all"	4 weeks and less	3,000 and less	$100.–$150.	"Absolute necessity"	C. E.	1	6	Surveying	None	"Urged"	None		0		8
9	Colorado State (Agr.)	85	All	Yes	None	"Variable"			"Very good"	None					None	Advised		4	Opt'l	9
10	Cornell Univ.	1,631	Electricals	No	"	4 and 5 days				None					"Many do. Wish more did"	None		0		10
11	Dartmouth Coll.		All	No	"	3–5 days	250	$18.00+	"Successful"	None					"Impracticable"	For C. E. degree	Geology	0		11
12	Delaware Coll.	111	Seniors	Yes	None	2 "	120		"Satisfactory"	All	1	2	Surv. and shop	"Not found necessary"	"Many do"	None		0		12
13	Iowa State Coll.	587	All courses junior and senior	No	"	1 week	800	$35.	"Full value"	Min. Eng'r	2	6	Mine surv. and inspection	"Practical work of twice the time"	"Advised"	"		1	Yes	13
										C. E.	3	6	Surv.	Summer work except soph. camp	Required 2 summers if camp not attended	"				
14	Kas. State Agr. Coll.	347	Senior C. E.	Yes	Good excuse and report	3 day	300	$12.–$15.		Not yet					"Many do"	"		4	"	14
15	Leland Stanford		None	No						"Geology and mining students"					"Many do"			1+	Yes and no	15
16	Maryland Agr.	73	C. E.							None					None			0		16
17	Mass. Inst. Tech.	891	Juniors and seniors All	No	Variable	Local			"Well attended"	C. E. and San. E.	1	7	Surveying	"Rarely excused"	"Advised to do so"	100 points	History, science, etc.	0		17
										Min. E.	1	1	"						
										Chem.	1	5	Qualitative anal.						
18	McGill Univ.		Min. E.	Yes	Acceptable work	4–6 weeks	5,000	$110.		All	Too elaborate to tabulate. See catalog.				Arch. for 5 weeks Others expected to	3 summers	Cultural and technical	0		18
19	Mich. Agr.	440	Seniors	No		5–6 days	1,000	$40.	"Beneficial"	None					"Advised"	None		2	Yes	19
20	Mich. Coll. Mines	222	All	No	None for min.	5 weeks and less	500	$75.00	"Best part of course"	All	Regular summer terms				None	"		0		20
21	Mont. State Coll.	58	All	No		1 day	Short	$15.00	"Exceedingly profitable"	None	"Not required as nearly all engage in practice"				"Nearly all do"	"		1	"	21
22	Mont. State Sch. Mines	60	Min. E.	Yes	None	Too elaborate to tabulate				Mining eng'r's	2	20			"			0		22
23	N. H. State Coll.	105	All	No		3–4 days	200	$25.	"Great good"	None					None	None		0		23
24	N. Mexico Coll. Agr. and Mech. Arts	5	None	No						None					None	None		0		24
25	N. Dakota Agr. Coll.	35	Not fully organised							None					"Many do"	None		0		25
26	Northwestern Univ.		All	No		1 day and less	300	$4.00	"Considerable good"	All	4	24	Surv., lab., shop	"Never excused"	"Many do"	None		2	Opt'l	26
27	Norwich Univ.		Geology and C. E.	Yes	None	50	50			C. E. and E. E.	3	10	Surv.	Six weeks of like work	"Strongly advised"	"		0		27
28	Ohio State Univ.	706	All but C. E.	"	Reading course	1 week	800	$35.00	See letter	C. E.	2	8	Surv.	None	"Advised strongly"	"		0		28
										Architects.	1	6 od.	Architect's office	One problem					
										Others	1	4	Shop	None					
29	Ohio Univ.	131	Sophs.	"		1–2 days	60	$5.–$10.	"Very successful"	None					None	"		0		29
30	Okla. Agr. Coll.	156	Experimenting							"					"	"		1	Yes	30
31	Ore. Agr. Coll.	222	All	E. E. and M. E. seniors	None	5 days	250	$15.	"Good"	"					"Impracticable"	"		2	"	31
32	Pa. State Coll.	771	Seniors	Yes	Special lab.	1 week	800	$40.	"Indispensable"	All	6 credits in actual practice or pursue some approved study					"		0		32
33	Purdue Univ.	1,212	Seniors and juniors	"	None	3 days		$10.–$20.	"Very satisfactory"	Civils	1	4	Surv.	Illness	"Advised"	"		2	"	33
34	Rhode Island State		All	No		3 "	200		"Considerable benefit"	None					"None"	"		1	"	34
35	Rose Poly. Inst.		"	Yes	None			$15.–$25.	"Good"	Civils	1	2	R. R. surv.	"Equivalent work of 4 times duration. Must be reported"	"90% do"	"		0		35
36	Rutgers Coll.	156	"	"	"	3 days	100		"Invaluable"	C. E.	2	4	Surv.	"Work of same character"	None	"		0		36
										E. E. and M. E.	2	4	Lab.	"Rarely"					
37	S. D. Sch. Mines	41	Freshmen	"	"	1 week	200	$40.	"Very satisfactory"	Juniors	2	5	Surv. and met. lab.	None	"75% do"	"		0		37
			Seniors	"	1 yrs. work	1 week														
38	State Univ. of Iowa		Seniors	"	None	1 week	600	$40.	"Excellent"	None					None	"		0		38
39	State Coll. of Wash.		C. E., E. E., Min. E., J. and S.	"	"	1–2 weeks	100–300	$20.–$50.	"Very successful"	"					"Practically all do"	Conditioned students	Stimulant	1+	"	39
40	Stevens Inst. Tech.	161	All	"	Short trip	1 week	1,200	$70.	" "	All	Regular supplementary June term				None	None		0		40
41	Swarthmore Coll.		"	"	None	1 day	Local	$1.	"Great success"	None					"50% do"	"		2	"	41
42	Syracuse Univ.		"	No		3 days	280	$5.–$10.	"Very successful"	All	6 months with correspondence courses			Rarely		"		1	"	42
43	Tufts College		"	Yes	None	Local			"Very important"	None					"Many do"	"				43
44	Univ. of Alabama		Some	Not yet but soon		3–4 days		$25.00	"Believe in it"	"					None	"		1	"	44
45	" " Ark.	236	Elec. E.	Yes	Design					Civil E.	3	3	Surv.		Min. E. 2 summers	"		0		45
46	" " Cal.		Some	No		1 day	200 and less		"Successful"	All fresh.	1	4	"	None	"Advised"	"				46
										jr. C. E.	1	4	" R. R.							
47	" " Colo.		Seniors and juniors	Yes	None	In Colo. one week			"	None					"Majority do"	60 points	Cultural	1	Yes	47
48	" " Fla.	40	E. E. and M. E.	No		3 days	200	$8.	"Well worth while"	"					"Offer every encouragement"	None		0		48
49	" " Idaho	90	All	Mining E.	"		B. C.		"Very good"	"					Mining 3 months	"		4	"	49
50	" " Ill.	1,064	All	No			250	$25.	"Worth while"	"					"Urge it"	50 points	"	1	Yes	50
51	" " Kas.	435	All	Yes	Very rare	1 week	800	$40.	"Great value"	C. E. and Min. E.	1	4	Surv.	Equiv. in actual practice	M. E. 6 weeks	"		1	"	51
										E. E. and M. E.	1	4	Shop						
52	" " Maine	289	All	No	Probs., etc.	1 week and less	600—	$20.	"Very good"	C. E.	1	2	Surv.	None	"Advised"	None		0		52
53	" " Minn.	537	All	Yes	None	Local	Local	Nominal	"Successful"	C. E.	1	5	Surv.	Rarely	"Now considering it"	None				53
54	" " Miss.	32	None	No						None					None	None		0		54
55	" " Mo.	877	Seniors and juniors	No		4–5 days	Chicago	$25.	"Very much worth while"	C. E.	2	4	Surv.	Rarely	"75% do"	"		1	Yes	55
										Min. E.	1	2 etc.	" etc.						
56	" " Mont.	1	Seniors	Yes	None	1 week	300	$25.	"Very successful"	C. E.	1	2	"		None	"		1	"	56
57	" " Neb.	412	All	No		3 days	200	$10.–$40.	"Satisfactory"	None					"Majority do"	"		0		57
58	" " Nev.	90	All	No		"	100	$5.–$10.	"	C. E. and Min. E.	1	4	Surv., geol., mining	None	4 weeks. Mining E.	None		0		58
59	" " N. Dak.		Min. E.	Yes	None	3 weeks	3,000		"Very successful"	None	Dept. places C. E. during summers				Informally req.	"		0		59
60	" " Okla.	45	Seniors	No		10 days	Chicago	$100.	" "	None					None	"		0		60
61	" " Ore.	138	All	E. E.	None	1 week	350	$25.	"Good"	None					"	"		0		61
62	" " Pa.		Seniors and juniors	No			10–150		"First trip"	Planning to have all surv. come summers					"			0		62
63	" " S. Calif.		C. E.	Yes	None	Local	Nearby	Nominal	"Excellent"	C. E.	1	4	Surv.	Equiv. in practice	"	Freshmen.	See letter	0		63
64	" " Tenn.	125	All	Yes	Rarely	2–4 days	100–200	$5.–$25.	"Extremely good"	None					"40% do"	None		2	Opt'l	64
65	" " Texas	13	Seniors	Yes	Practical	10 "		$25.	"Excellent"	M. E. and E. E.	"Equiv. of 1 term's work at school or outside" Climate O. K.				None	"		0		65
66	" " Vermont	133								None					"Nearly all do"	"		0		66
67	" " Wash. (Mines)	466	Juniors and seniors	Yes	Illness-rep.	10 days	200–400	$30.	"Successful"	C. E.	3	12	Surv.	Rarely	None	"		0		67
										None					Min. E. one summer	Expected		0		
68	" " Wis.	763	Min. E.	Yes	Rarely	5 weeks	Mich.	$55.+	"Beneficial"	C. E.	1	4	"		See before	None		0		68
			All others			1 week	Buffalo			Min. E.	1	6	"	Equiv. in actual practice					
										All others	1	4	Shop						

														Necessary"		None		0		12
									Min. Eng'r	2	6	Mine surv. and inspection	"Practical work of twice the time"	"Advised"	"		1	Yes	13
									C. E.	3	6	Surv.	Summer work except soph. camp	Required 2 summers if camp not attended	"				
14	Kas. State Agr. Coll.	347	Senior C. E.	Yes	Good excuse and report	3 day	300	$12.–$15.		Not yet					"Many do"	"		4	"	14
15	Leland Stanford		None	No						"Geology and mining students"					"Many do"			1+	Yes and no	15
16	Maryland Agr.	73	C. E. Juniors and seniors							None					None			0		16
17	Mass. Inst. Tech.	891	All	No	Variable	Local			"Well attended"	C. E. and San. E.	1	7	Surveying	"Rarely excused"	"Advised to do so"	100 points	History, science, etc.	0		17
										Min. E.	1	1	"							
										Chem.	1	5	Qualitative anal.							
18	McGill Univ.		Min. E.	Yes	Acceptable work	4–6 weeks	5,000	$110.		All	Too elaborate to tabulate. See catalog.				Arch. for 5 weeks Others expected to	3 summers	Cultural and technical	0		18
19	Mich. Agr.	440	Seniors	No		5–6 days	1,000	$40.	"Beneficial"	None					"Advised"	None		2	Yes	19
20	Mich. Coll. Mines	222	All	No	None for min.	5 weeks and less	500	$75.00	"Best part of course"	All	Regular summer terms				None	"		0		20
21	Mont. State Coll.	58	All	No		1 day	Short	$15.00	"Exceedingly profitable"	None	"Not required as nearly all engage in practice"				"Nearly all do"	"		1	"	21
22	Mont. State Sch. Mines	60	Min. E.	Yes	None	Too elaborate to tabulate				Mining eng'r's	2	20			"			0		22
23	N. H. State Coll.	105	All	No		3–4 days	200	$25.	"Great good"	None					None	None		0		23
24	N. Mexico Coll. Agr. and Mech. Arts	5	None	No						None					None	None		0		24
25	N. Dakota Agr. Coll.	35	Not fully organized							None					"Many do"	None		0		25
26	Northwestern Univ.		All	No		1 day and less	300	$4.00	"Considerable good"	All	4	24	Surv., lab., shop	"Never excused"	"Many do"	None		2	Opt'l	26
27	Norwich Univ.		Geology and C. E.	Yes	None	50	50			C. E. and E. E.	3	10	Surv.	Six weeks of like work	"Strongly advised"	"		0		27
28	Ohio State Univ.	706	All but C. E.	"	Reading course	1 week	800	$35.00	See letter	C. E.	2	8	Surv.	None	"Advised strongly"	"		0		28
										Architects.	1	6 od.	Architect's office	One problem						
										Others	1	4	Shop	None						
29	Ohio Univ.	131	Sophs.	"		1–2 days	60	$5.–$10.	"Very successful"	None					None	"		0		29
30	Okla. Agr. Coll.	156	Experimenting							"					"	"		1	Yes	30
31	Ore. Agr. Coll.	222	All	E. E. and M. E. seniors	None	5 days	250	$15.	"Good"	"					"Impracticable"	"		2	"	31
32	Pa. State Coll.	771	Seniors	Yes	Special lab.	1 week	800	$40.	"Indispensable"	All	6 credits in actual practice or pursue some approved study					"		0		32
33	Purdue Univ.	1,212	Seniors and juniors	"	None	3 days		$10.–$20.	"Very satisfactory"	Civils	1	4	Surv.	Illness	"Advised"	"		2	"	33
34	Rhode Island State		All	No		3 "	200		"Considerable benefit"	None					"None"	"		1	"	34
35	Rose Poly. Inst.		"	Yes	None			$15.–$25.	"Good"	Civils	1	2	R. R. surv.	"Equivalent work of 4 times duration. Must be reported"	"90% do"	"		0		35
36	Rutgers Coll.	156	"	"	"	3 days	100		"Invaluable"	C. E.	2	4	Surv.	"Work of same character"	None	"		0		36
										E. E. and M. E.	2	4	Lab.	"Rarely"						
37	S. D. Sch. Mines	41	Freshmen	"	"	1 week	200	$40.	"Very satisfactory"	Juniors	2	5	Surv. and met. lab.	None	"75% do"	"		0		37
			Seniors	"	1 yrs. work	1 week														
38	State Univ. of Iowa		Seniors	"	None	1 week	600	$40.	"Excellent"	None					None	"		0		38
39	State Coll. of Wash.		C. E., E. E., Min. E., J. and S.	"	"	1–2 weeks	100–300	$20.–$50.	"Very successful"	"					"Practically all do"	Conditioned students	Stimulant	1+	"	39
40	Stevens Inst. Tech.	161	All	"	Short trip	1 week	1,200	$70.	" "	All	Regular supplementary June term				None	None		0		40
41	Swarthmore Coll.		"	"	None	1 day	Local	$1.	"Great success"	None					"50% do"	"		2	"	41
42	Syracuse Univ.		"	No		3 days	280	$5.–$10.	"Very successful"	All	6 months with correspondence courses			Rarely		"		1	"	42
43	Tufts College		"	Yes	None	Local			"Very important"	None					"Many do"	"				43
44	Univ. of Alabama		Some	Not yet but soon		3–4 days		$25.00	"Believe in it"	"					None	"		1	"	44
45	" " Ark.	236	Elec. E.	Yes	Design					Civil E.	3	3	Surv.		Min. E. 2 summers	"		0		45
46	" " Cal.		Some	No		1 day	200 and less		"Successful"	All fresh.	1	4	"	None	"Advised"	"				46
										jr. C. E.	1	4	" R. R.							
47	" " Colo.		Seniors and juniors	Yes	None	In Colo. one week			"	None					"Majority do"	60 points	Cultural	1	Yes	47
48	" " Fla.	40	E. E. and M. E.	No		3 days	200	$8.	"Well worth while"	"					"Offer every encouragement"	None		0		48
49	" " Idaho	90	All	Mining E.	"		B. C.		"Very good"	"					Mining 3 months	"		4	"	49
50	" " Ill.	1,064	All	No			250	$25.	"Worth while"	"					"Urge it"	50 points	"	1	Yes	50
51	" " Kas.	435	All	Yes	Very rare	1 week	800	$40.	"Great value"	C. E. and Min. E.	1	4	Surv.	Equiv. in actual practice	M. E. 6 weeks	"		1	"	51
										E. E. and M. E.	1	4	Shop							
52	" " Maine	289	All	No	Probs., etc.	1 week and less	600 —	$20.	"Very good"	C. E.	1	2	Surv.	None	"Advised"	None		0		52
53	" " Minn.	537	All	Yes	None	Local	Local	Nominal	"Successful"	C. E.	1	5	Surv.	Rarely	"Now considering it"	None				53
54	" " Miss.	32	None	No						None					None	None		0		54
55	" " Mo.	577	Seniors and juniors	No		4–5 days	Chicago	$25.	"Very much worth while"	C. E.	2	4	Surv.	Rarely	"75% do"	"		1	Yes	55
										Min. E.	1	2 etc.	" etc.							
56	" " Mont.	1	Seniors	Yes	None	1 week	300	$25.	"Very successful"	C. E.	1	2	"		None	"		1	"	56
57	" " Neb.	412	All	No		3 days	200	$10.–$40.	"Satisfactory"	None					"Majority do"	"		0		57
58	" " Nev.	80	All	No		"	100	$5.–$10.	"	C. E. and Min. E.	1	4	Surv., geol., mining	None	4 weeks. Mining E.	None				58
59	" " N. Dak.		Min. E.	Yes	None	3 weeks	3,000		"Very successful"	None	Dept. places C. E. during summers				Informally req.	"		0		59
60	" " Okla.	45	Seniors	No		10 days	Chicago	$100.	" "	None					None	"		0		60
61	" " Ore.	138	All	E. E.	None	1 week	350	$25.	"Good"	None	Planning to have all surv. come summers				"	"		0		61
62	" " Pa.		Seniors and juniors	No			10–150		"First trip"	C. E.	1	4	Surv.	Equiv. in practice	"	Freshmen.	See letter	0		62
63	" " S. Calif.		C. E.	Yes	None	Local	Nearby	Nominal	"Excellent"	None					"40% do"	None		2	Opt'l	63
64	" " Tenn.	125	All	Yes	Rarely	2–4 days	100–200	$5.–$25.	"Extremely good"	M. E. and E. E.	"Equiv. of 1 term's work at school or outside"				None	"		0		64
65	" " Texas	13	Seniors	Yes	Practical	10 "		$25.	"Excellent"	None			Climate O. K.		"Nearly all do"	"		0		65
66	" " Vermont	133								C. E.	3	12	Surv.	Rarely	None	"		0		66
67	" " Wash. (Mines)	466	Juniors and seniors	Yes	Illness-rep.	10 days	200–400	$30.	"Successful"	None					Min. E. one summer	Expected		0		67
68	" " Wis.	763	Min. E.	Yes	Rarely	5 weeks	Mich.	$55.+	"Beneficial"	C. E.	1	4	"	Equiv. in actual practice	See before	None		0		68
			All others			1 week	Buffalo			Min. E.	1	6	"							
										All others	1	4	Shop							
69	" " Wyo.	25	None needed on account of practical work done							No work required for same reason					"All do"	"		0		69
70	Vanderbilt Univ.		All	Yes	None	Local	Short	Nominal	"Very good"	None					"Majority do"	"		0		70
71	Washington Univ.		All	Yes	None	"	"	"	"Very desirable"	C. E.	2	6	Surveying	1 summer maybe	"Majority do"	"		0		71
										Architects	1	6	In architect's office	Problem						
72	West Va. Univ.	89	C. E.	No		Reasonable			"Profitable"	Jr. C. E.	1	5	Surveying	3 mos. practice	"Majority do"	"		0		72
73	Worcester Poly.		C. E.	Yes	None	1 day	5–50	$3.	"Fair"	C. E.	3	9	"	Similar practice	"Many do"	"		0		73
74	Yale		All seniors	Yes	"	1 week		$50.	"Eminently successful"	C. E., San. E., E. E., Min. E. and Fy. M. E.	1	3	Mech. lab., etc.	None	"Graduate students"			1	Yes	74
75																				75

Univ. of Maine College of Technology, Mar. 1914. J. E. K.

ORDER IN WORKING OUT PROBLEMS IN MECHANICS.

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The average student of elementary mechanics who goes to the blackboard to work out a numerical problem applies all four of the arithmetical operations to the numbers involved before he considers the dynamics of the problem. When his arithmetical powers are exhausted he turns to consider the real problem only to find that it is time for the discussion of the problem before the class. Sometimes he succeeds in getting some kind of a solution but in this case the blackboard is covered with such a mess of long divisions and multiplications that the instructor finds it difficult to find the line of reasoning used, while the class find it impossible to follow the discussion.

It seems to me that these difficulties can be avoided to a great extent if the student is made to follow certain directions which will constrain him to consider the dynamics of the problem before plunging into arithmetical operations. I have used the following set of directions in my classes and found them very helpful. They not only help the student think clearly and consistently in working out his problem but also enable the class to follow the discussion.

It will be observed that both in the directions and the illustrative examples I have laid emphasis upon keeping numerical values out of the main line of reasoning and upon introducing them only after a simple expression of the required magnitude is obtained in terms of the given magnitudes. This is a point worth the serious consideration of instructors of mechanics. Arithmetical equations involving many figures and different units are clumsy compared with algebraic equations which express the same relation among the several dynamical magnitudes. Therefore the student should be en-

couraged to do his thinking in the shorthand language of analysis and to use his arithmetic only after he has solved the problem. In other words, he should be trained to treat numerical problems as if they were non-numerical.

Directions for Students of Mechanics.

1. Draw a figure in the upper right-hand corner, select the particle (or body) the equilibrium or motion of which is to be considered, represent all the forces acting upon the particle by vectors, and label them.

2. Select a system of axes which will make the dynamical equations as simple as possible.

3. Tabulate the given and the required magnitudes under the figure, giving the numerical values of the known magnitudes with the proper units.

4. Write down the dynamical equations and any definitions or geometrical relations which may be necessary, on the upper left-hand corner.

Note.—When the analytical definition of the required magnitude leads directly to an expression involving only the given magnitudes it may be desirable to neglect No. 3 and to take the definition as the starting point of the analysis.

5. Solve the dynamical equations for the required quantities. Be sure that they are expressed in terms of the given magnitudes in the simplest form.

6. Replace the letters representing the different magnitudes by their numerical values, with the proper units.

7. Segregate the numbers and the units.

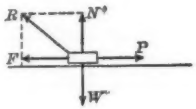
8. Convert the units to those in which you want to have the required magnitude expressed.

9. Compute by logarithms, or slide rule, the numerical part thus obtained; or simplify by cancelling, factoring, etc., and obtain the result by computation (at least approximately).

10. Discuss the results in non-numerical problems.

ILLUSTRATIVE EXAMPLES:

A weight of 75 pounds rests on a rough horizontal floor. Find the magnitude of the least horizontal force which will move the body if the coefficient of friction is 0.4; also find the reaction of the plane.



$\Sigma X \equiv P - F = 0,$
$\Sigma Y \equiv N - W = 0,$
$F = \mu N.$
$\therefore P = F$
$= \mu N$
$= \mu W$
$= 0.4 \times 75$ lbs.
$= 30$ lbs.

Given.
$W = 75$ lbs.
$\mu = 0.4$
$P = ?$
$R = ?$
$\phi = ?$

$F = 30$ lbs.

$N = 75$ lbs.

$R = \sqrt{F^2 + N^2}$
$= \sqrt{30^2 + 75^2}$ lbs.
$= 15\sqrt{4 + 25}$ lbs.
$= 80.7$ lbs.

$\phi = \tan^{-1} \mu$
$= \tan^{-1} 0.4$
$= 21° .5$

Find the horse power developed by an engine which moves a train at the rate of 30 miles an hour up an incline of 1 in 300. The train weighs 120 tons and there is a resistance of 15 pounds per ton.

$$P = \frac{W}{t}$$

$$= \frac{F.S}{t}$$

$$= (mg.\sin\alpha + R)\frac{s}{t}$$

$$= (mg.\sin\alpha + r)v$$

$$= 120 \times 2000 \text{ lbs.} \left(\frac{1}{300} + \frac{15}{2000}\right) 30 \frac{\text{mile}}{\text{hr.}}$$

$$= 120 \times \overset{10}{20}\frac{13}{30}\, 30 \frac{\text{mile lb.}}{\text{hr.}}$$

$$= 10 \times \overset{10}{20} \times 13 \times 30 \frac{5280 \text{ ft. lb.}}{60 \text{ min.}}$$

$$= 10 \times 10 \times 13 \times \overset{16}{5280} \frac{\text{ft. lb.}}{\text{min.}} \frac{1 \text{ H.P.}}{33000 \frac{\text{ft. lb.}}{\text{min.}}}$$

$$= 208 \text{ H.P.}$$

Given.

$v = 30 \frac{\text{mile}}{\text{hr.}}$

$mg = 120$ tons.

$\alpha = \sin^{-1}\frac{1}{300}$

$r = 5 \frac{\text{lb.}}{\text{ton}}$

$P = ?$

DISCUSSION OF "ELECTRICAL ENGINEERING LABORATORY INSTRUCTION."

BY R. W. GODDARD,

Professor of Electrical Engineering, State College of New Mexico.

The system of laboratory instruction described by Professor Munro in the November BULLETIN and more fully explained in this issue appeals to me as one especially fitted for teaching advanced students in small numbers, but hardly suitable for beginners or large classes.

Its successful operation depends upon the possibility of a single set-up for a complete "study" without the apparatus or instruments being disturbed throughout the time required. In many of our universities and colleges, each class, for laboratory work, is necessarily divided into divisions which are subdivided into groups. Each division reports for work on different afternoons and for economy of apparatus, instruments, and space, these have to be used successively by the different divisions. It is not easy to conceive of each group in every division progressing with the same rapidity so that exactly the same set-up could be utilized by each, changing it as the work progressed. Even if this was possible the whole value of the method would be lost, on the one hand by only one group making the set-up, and on the other hand by its disturbance by each successive group using it. The only alternative I see is duplication as many times as there must be divisions. From the instruction point of view this would be ideal, but it is hardly possible with many colleges.

The "semi-intensive scheme" of putting all the senior laboratory in the first semester to avoid conflict with junior laboratory, which is given as usual in the second semester, would seem to have some serious drawbacks.

In the first place, I believe it is common practice in many

schools for the study of alternating current circuits and phenomena to begin with the senior year, covering the general theory the first semester and its practical application in machinery the second. Under these circumstances the student would hardly be prepared for such studies as the circle diagram for the transformer, the induction motor, rotary converter, and numerous others found in the list of experiments of nearly all laboratory courses.

Then again I believe it is well to spread out and sandwich practice courses in with those requiring more intense application like alternating current theory, etc. It helps to break the monotony and relieves that nervous tension a conscientious student is almost constantly under in this high speed age.

Lastly, I find that a large majority of my students do not begin to really wake up to see the serious side of life until along in the senior year. A marked change in their attitude towards the work makes itself manifest at this time. It is after this that they do their best, and since we are all agreed that few courses excel a well planned and executed series of laboratory investigations in possibilities for development, why remove such courses from our curriculum just at the time when they become most effective.

Several practices mentioned appear to me as most excellent. The use of every possible protection for apparatus and line so that results of wiring can be left to the students; the series of counter-questions leading to the deduction of an answer to an inquiry; the grouping of numerous tests on a particular class of machines into a "study"; the use, so far as is practical, of standard commercial tests; and the shorter, concise report with especial emphasis on the interpretation of the data obtained.

DISCUSSION OF "ELECTRICAL ENGINEERING LABORATORY INSTRUCTION."

BY MELVILLE S. MUNRO,
Assistant Professor of Electrical Engineering, Tufts College, Mass.

I was gratified to find that my article of the above title in the November BULLETIN started a discussion. It seems to me that if we could air our views and methods of instruction in the BULLETIN and obtain good healthy discussions upon them it would be very beneficial. We might aid others by explaining our methods and secure valuable suggestions from the discussion of them in return.

I think that the adverse criticism of the method we are trying to develop at Tufts College, as noted in the January BULLETIN, is very largely due to a misunderstanding as to the methods of administrating it. When I sent in the paper I hardly expected much discussion, so did not enter into its details to any great extent. Since it has drawn both favorable and adverse comment I think in justice to the method it should be more minutely explained, and so would offer the following remarks as supplementary to the original paper and to some extent show why it is that the application of our practice does not seem to me to offer the evils suggested.

I will agree, as we all must, that what we can do with small classes or small groups cannot always be effectively done with large ones, therefore our method finds its most efficient field in small classes or at least with classes that can be subdivided into small unit groups. Also where the instructor can keep close oversight of what is being done with the equipment. The method would find use in the larger laboratories only in the more advanced work, as suggested by Professor Hollister.

We do not start the junior when he comes to us immediately upon his own responsibility as to choice of apparatus and methods. At this time he has no experience upon which to

base his judgment. We try to develop this judgment, which usually means that as a senior in the laboratory he becomes quite free and is on the whole far enough advanced to exercise considerable care and judgment.

While at first sight it may appear that the method of conducting the work savors of the "manual training or shop courses," in practice it does not work out that way at all. Let us assume that a group of three men are about to undertake the study of a direct current generator. The apparatus will consist of the generator, usually compound wound, so that the entire study of a series of tests can be made with the same generator, and a motor to drive it. There will also be all the necessary auxiliaries for the measurements and control. The first laboratory period (three hours) will be devoted to the discussion of the general plan of procedure and the introductory test; all further discussion comes at the time it is needed. The latter part of the period will be taken up by choosing and arranging the apparatus and such preliminary operation as will indicate whether the speed range is proper as well as the mechanical details. Sometimes it may take the greater part of two periods to get the set in proper condition for the study depending upon the length of the discussion and the speed of the men. The machinery and all its accessories will belong to this group of men for the entire time devoted to the experimental work independent of the time it will take to complete the work. No one will have occasion to use any of the equipment, so that at the end of the period the apparatus is left entire. It is not our custom to permit knocking down any of the wiring or replacing the meters in the closet. The table containing the control and measuring devices is covered with a cloth and left so that at the next period the work can be continued, only making such changes in the wiring as may be found necessary to carry on the different tests. In the main however it is rarely necessary to change the set-up of the machinery itself. Thus in the application of the method as we are using it I think we spend no more time and perhaps even less time than when we required the wiring to be either

taken down or at least seriously interfered with when it was impossible to leave the set-up over from day to day.

Permanently set up apparatus and wiring we never favored, although we can see where it may be desirable in the larger laboratories. As to possible loss or injury to instruments left out in this manner we have had no trouble whatever in the three years we have been developing the scheme. When not in use the laboratory is locked up and no one has need to go there except responsible parties. Shop and manual training courses are to my mind very much to be questioned in our college curriculum except in the specific field of shop-work theory.

We have been able to apply the group system and use of apparatus by making a very radical change in the administration of the laboratory work. This change I think is of sufficient importance to warrant a few words as it explains why the method works when at first sight it might suggest a great variety and duplication of apparatus.

Several years ago we found that our equipment was fast becoming insufficient for our needs. Upon analysis of the situation we found the trouble largely due to the fact that there was interference between the senior and junior laboratory work and also lack of space in which to expand. At that time both laboratory courses were scheduled for two periods per week for a year, so that the equipment was likely to be more or less fully in demand by both groups so that it was almost impossible to hold over a set-up of apparatus from one day to the next. To relieve this condition we adopted what might be called a semi-intensive scheme. We put our senior laboratory work entirely in the first semester, using three periods per week instead of two. While this actually cut down the time in the laboratory, owing to the intensive arrangement of the work and the ability to have the entire equipment of the laboratory at the disposal of the seniors we actually cover more ground than we did formerly. In addition we subdivide the character of the work so that there is no interference between the several types of tests which may be

going on simultaneously. Another advantage of this arrangement is the removal of the laboratory work from the second semester, which then gives more time for the consideration of thesis, or as is anticipated when the need arises, a course in advanced laboratory which will need a more or less special equipment.

The second semester is now free for the junior laboratory work and the entire equipment of the laboratory is free as well. Lack of space for expansion was relieved by the adoption of the slotted floor as explained in my previous article.

I would emphasize the point again that after the machinery is once set up it only requires minor changes for an entire study. This is one of the advantages of the "study" group system as all the tests are grouped so that the minimum movement of machinery accomplishes a maximum of results. The study of the direct current generator before mentioned may extend over a number of weeks time without any noticeable changes in the set-up of the machinery although the character of the wiring will undergo many changes.

In answer to the point raised as to requiring "rather complete written reports" I would say that it has been my experience with sophomores in the physics laboratory and with juniors and seniors in the electrical laboratory that the average student either is not capable or does not have the time, under pressure of his varied tasks, to completely digest any given test, its theory, methods, interpretation, etc., to give in his own words a good demonstration. I may have been peculiar in the standards required for such reports or unfortunate in the results obtained but the average report by a student who has access to texts on the subject so savors of his favorite author that the instructor can quite readily determine the source of the information. That is, the student largely copies, unconsciously perhaps, the matter we would have him get out of his own head. If the report is not accepted when too "booky" and must be done over again the student is almost lost and usually passes in something which is of no particular credit to him.

Since we consider in discussion all the points in theory and the correlation of results with theory or theory with results I feel that it is more important for the student to enter into these discussions, thereby developing his initiative, than it is to spend his time copying from his texts or so jumbling the interpretation of the text as to have his written work "get by." I do not mean to say that good results cannot be obtained. I will admit that if we have the time to get original reports from the men that the time is well spent in so doing: if we cannot get original reports I feel that at least in my interpretation of the field of the course that the time can be better put to training the mind in the analysis of results which comes about by the exchange of ideas in the discussions. I find the men enter heartily into such discussions where they are only "lukewarm" when it comes to sitting down to a long written report. It may be contended that the writing of reports is a necessary part of the training of the engineer and I think we will all admit it but in any case we individually must choose those methods which seem to best serve us in the furthering of our aims.

In the application of this method of conducting the laboratory work we do not require any definite schedule of tests to be done by every man for credit in the work. Of course any instructor sees to it that his men do not "loaf on the work" and that they employ their time as profitably as possible. It is my contention that the function of the laboratory course is to aid in developing the mind of the man and not the fulfillment of a certain quantity of work. It is of secondary importance to me to know that a man has done, say, fifteen tests and passed in presentable reports when I know that he has not obtained much intellectual growth by the performance of those tests. What I want to know is whether the man in performing any number of tests has done the work faithfully and to the best of his ability and obtained some addition to his mental capacity in the doing of them. If he has, then I think that the real object of his taking the course has been accomplished. Incidentally, or perhaps I should say of secondary importance,

if he has acquired any specific knowledge concerning machinery, its action, theory, etc., so much the better. It is rare to find a case where the two requirements are not both met however.

When the student comes to us, as his teachers, his mind is in a more or less plastic state and it is our duty to so mould that mind as to fit him to take up whatever work he is called upon to do in whatever field chance may place him. We must train the man to use his brain, to think for himself, to correlate ideas, results, analyze conditions. We must stir up his mental activity under the guidance of our courses, using our particular subjects as the means. If in the span of time of our individual courses we find that the student responds to our guidance I believe we should feel very much encouraged. If in addition he shows proficiency to a greater or lesser degree in the subject matter so much the better. To show that the content of the course is secondary, we can all of us probably cite cases where men making one type of work a major very often attain excellent standing in other lines of work after graduation.

In closing I would repeat again my statement in the former paper that I believe the laboratory offers an unusually good place to show indications of intellectual growth along lines of initiative, application, analysis and self-reliance and it is our duty as laboratory instructors to so enter into the spirit of our work as to encourage any signs of such growth as may come to our attention.

903: A graduate civil engineer, M.Am.Soc.C.E., with ten years experience in responsible positions on design and construction of large hydraulic, railroad, reinforced concrete works; with three years experience in teaching various engineering subjects; and who has, for the past year, been making advanced studies in Education; desires a teaching position commensurate with training and experience. Creditable references and details on request.

ANNOUNCEMENT

The Summer School of Management, Third Year. A summer course in Scientific Management will be held for three weeks during August, 1915, in Providence, R. I. This course is especially designed for professors of Engineering, Economics, Psychology, and Business Administration. For further particulars apply to Frank B. Gilbreth, 77 Brown Street, Providence, R. I."